CROSS TALK

▶**COLOR . . .** Color ads appearing in national magazines depicting the wonders of television have a lot of us drooling, just in anticipation. The trouble is that many people are going to experience a distinct shock when they see their first demonstration and find out that television is not in full color—as in the ads—but in black and white. Careful reading of the ads discloses no claim or promise but the implication is there just the same. Isn't it just possible that this color advertising will create sales resistance for the dealers and make more difficult their problem of transferring the products of the manufacturers to the homes? As a matter of cold fact, won't the mere promise of color delay the distribution of the black-and-white receivers?

▶**BD . . .** As of May 1, this year, Beverly Dudley leaves his post as Western Editor of ELECTRONICS and becomes editor of The Technology Review, alumni technical journal of the Massachusetts Institute of Technology. "Dud" had been on the editorial staff of ELECTRONICS for eight years, first as associate editor, then 2½ years as managing editor and since October of 1944 he has been in Chicago, where he was actively engaged in making and keeping friends for his paper when the opportunity came along to return to his Alma Mater as a member of its administrative staff.

▶**FM . . .** For the record, Major E. H. Armstrong wishes it known that he was wrongly quoted by some of the newspapers and others at the time of the FCC hearings on f-m. It was stated that he would forego his royalties for a period of a year if f-m remained in the frequency band where it now is. Actually, as shown by the record of the proceedings, he said that if f-m went up to the 80-100 megacycle region, he felt large-scale use of f-m would be delayed for a year. Under these conditions he would turn over his royalties to a Board to use as seemed fitting.

Thus the newspaper reports were exactly opposite to the actual offer.

▶**SURPLUS . . .** Among the vast quantities of surplus and used equipment which the armed forces will ultimately release for sale will be much electronic apparatus which could be useful to colleges. The government could, in slight measure, repay many of the institutions of learning for their war-time aid by making it easy to purchase measuring apparatus, typical radio and radar demonstration units, tubes and all sorts of electronic stuff. Financially, colleges will be in no better condition after the war than they are now, and much of the equipment they need for proper instruction of the on-coming electronic experts will be out of sight economically if purchased first-hand. Disposing of the used or surplus material in this manner should annoy few manufacturers.

To prevent misuse of the purchase at low prices, all this educational gear could be so labelled. Sale could be restricted to those institutions which have contributed through ASTP, V-12, ROTC or in other ways.

▶**INDEX . . .** One of the greatest service problems of the Editorial Department is to answer quickly and accurately the question, "When did you publish an article on such-and-such?". To aid us in our end of this problem, all the annual indexes since 1930 have been offset and bound into a sort of cumulative index of indexes. Readers who could use a copy of this super index can obtain it by writing the Editorial Department and enclosing seventy-five cents.

IMPORTANT

"Paper is a Number One war material shortage—because over 700,000 different *war* items are wrapped, packaged, labelled, tagged, or made from paper or container board. And the Pacific war, when it speeds up, will require stupendous amounts of paper and board since double and triple packing are required for protection against weather, insects, etc.

"*So please*—

(1) Share this magazine with friends since present demand can not be satisfied due to the paper shortage;

(2) When this magazine has served its purpose put into paper salvage;

(3) And look over your store room to get waste paper of any kind to put into paper salvage.

"Then you'll be doing an 'extra' to aid the war effort—and to speed victory."

Electronic Applications in Industry

A year's work among 796 manufacturing and service plants in 11 major industries determines the type and number of electronic devices at present in use. More light is thrown on the potential market by indications of interest among non-users and suggested new applications. Highlights of a 192-page report are given here

HOW EXTENSIVE is the present-day use of electronic equipment by industry? What is the potential market? To throw more light on these two questions the Research Department of the McGraw-Hill Publishing Company conducted a survey throughout 1944, and in early 1945 rendered a 192-page report*.

The report, which can only be highlighted here, does not profess to be a complete and cannot hope to be a final answer. A perfect answer to the first question would necessarily involve collection of data from every plant in every industry, obviously impractical if the report was to be completed in time to guide post-war planners and particularly so at a time when restrictions still bar researchers from some factory corners. And the answer to the second question will constantly change as industry becomes more and more familiar with what electronic equipment can do.

In spite of these qualifications, which suggest that facts presented in the report do not in every case ideally lend themselves to projection and certainly should not be employed in this manner without careful consideration of all the factors involved, it is felt that the study represents the best work on the subject to date. Some illuminating general conclusions can be safely drawn from it. For example:

While the present industrial users of electronic equipment are less numerous than the man in the street supposes, they are more numerous than many hard-boiled engineers within the electronic industry itself suspect. The number of duplicate units of electronic equipment found in factories employing such gear is greater than many surmise. While certain specific industries are larger users of electronic apparatus than others at the moment, interest expressed by non-users indicates that the potential market still spreads pretty much right across the board. Many industries with jobs to do that can best be done by means of electronic equipment are not aware of the fact that similar jobs are already being done with such gear, despite the publicity which the art has enjoyed since the outbreak of the war.

How the Survey Was Conducted

The survey was conducted among 796 readers of the following magazines:

American Machinist
Aviation
Business Week
Chemical & Metallurgical Engineering
Coal Age
Electrical Contracting
Electrical World
ELECTRONICS
Engineering & Mining Journal
Engineering News-Record
Factory Management & Maintenance
Food Industries
Power
Textile World

It was felt that the fields served by these Company publications represented a good if not a complete cross-section of industry. No attempt was made to weight replies in accordance with the total number of firms engaged in specific industries, as projection of figures was not contemplated. Nor was there any attempt to concentrate contacts among men holding specific jobs. Those furnishing data included management, engineering, production, maintenance and even sales personnel.

During the course of the survey it became evident that data was more readily obtainable from the larger companies, and the final report reflects this. It should be kept in mind when the report itself, or the figures extracted therefrom and presented in these columns, are scanned.

Tabulation of Results

The tabulation of results presented here, containing a mere fraction of the data contained in the report, presents highlights considered of particular interest to readers of ELECTRONICS. To facilitate study the following information relative to the tabulation is given:

The first column (*Function or Device*) is broken down into eight

* "Electronic Applications in Industry" ($2.50), Research Department, McGraw-Hill Publishing Company, Inc., 330 West 42nd St., New York 18, N. Y.

SUMMARY OF ELECTRONIC SURVEY

Function or Device	Present Users No. Co.	No. Dev.	Chief User	Potential Users No. Co.	Greatest Interest
Control					
Carrier Current	35	218	Elec. Util. (28)	29	Elec. Util. (26)
Combustion	18	57	Metal Work. (6)	28	Chem. Proc. (11)
Electrostatic Precipitation	50	267	Metal Work. (25)	51	Chem. Proc. (14)
Filament Carburization	3	3	Metal Work. (3)	—	—
Illumination	38	145	Elec. Util. (19)	14	Metal Work. (6)
Induction Heating	10	24	Metal Work. (9)	5	Metal Work. (5)
Level	35	227	Chem. Proc. (18)	31	Chem. Proc. (16)
Electric Load	16	55	Elec. Util. (8)	9	Elec. Util. (5)
Door	25	91	Metal Work. (13)	27	Metal Work. (11)
Motion	22	83	Chem. Proc. (8)	17	Metal Work. (7)
Motor	48	247	Metal Work. (31)	61	Metal Work. (22)
Application of Coatings	2	4	Misc. Mfg. (1)	4	Metal Work. (3)
Register	18	156	Food (6)	11	Misc. Mfg. (6)
Remote	11	37	Elec. Util. (5)	17	Elec. Util. (8)
Switching	11	67	Metal Work. (8)	8	Elec. Util. (3)
Synchronization	11	32	Elec. Util. (8)	10	Elec. Util. (7)
Temperature	131	1,504	Metal Work. (68)	65	Chem. Proc. (20)
Timing (exc. welding)	62	294	Metal Work. (30)	13	Metal Work. (4)
Train	2	82	Metal Work. (1)	4	—
Welding (timing)	130	2,034	Metal Work.(100)	39	Metal Work. (24)
Relaying	19	104	Metal Work. (7)	19	Elec. Util. (11)
Humidity	1	1	Misc. Mfg. (1)	13	Text. (5)
Flow	25	80	Chem. Proc. (13)	13	Chem. Proc. (8)
Moisture	5	32	Chem. Proc. (4)	5	Text. (2)
Elevator Levelling	6	14	———	3	———
Germ, Insect	5	31	Chem. Proc. (3)	7	Food (3)
Color	———	———	———	8	Chem. Proc. (4)
Pressure	1	3	Elec. Util. (1)	5	Chem. Proc. (2)
Frequency	5	5	Elec. Util. (4)	4	Elec. Util. (4)
pH	6	19	Chem. Proc. (5)	13	Chem. Proc. (5)
Misc.	12	45	Metal Work. (6)	5	Const. (2)
Counting, Sorting, Weighing					
Inspection for Missing Parts	1	4	Food (1)	14	Metal Work. (7)
Counting	31	112	Metal Work. (13)	53	Metal Work. (18)
Flaw Detection	17	259	Metal Work. (5)	42	Metal Work. (24)
Sorting and Grading	12	65	Metal Work. (9)	41	Metal Work. (9)
Insulation Testing	20	69	Elec. Util. (12)	12	Elec. Util. (8)
Metal Detection	23	118	Const. (12)	14	Misc. Mfg. (3)
Surface Analyzing	19	43	Metal Work. (17)	9	Metal Work. (7)
Weighing	11	86	Chem. Proc. (6)	35	Food (15)
X-Ray Inspection	42	97	Metal Work. (26)	18	Metal Work. (12)
Heating					
Ferrous and Non-Ferrous Metals	15	29	Metal Work. (13)	25	Metal Work. (16)
Ferrous Metals	46	89	Metal Work. (40)	52	Metal Work. (38)
Non-Ferrous Metals	22	61	Metal Work. (17)	25	Metal Work. (19)
Food Sterilization, Dehydration	———	———	———	23	Food (20)
Gluing, Drying Wood, etc.	5	7	Misc. Mfg. (3)	27	Misc. Mfg. (10)
Plastics	10	12	Chem. Proc. (6)	14	Metal Work. (8)
Rubber	———	———	Misc. Mfg. (1)	4	Chem. Proc. (2)
Sheet Materials	4	5	Metal Work. (3)	11	Chem. Proc. (5)
Textiles and Paper	2	2	Misc. Mfg. (2)	16	Text. (6)
Misc.	6	12	Chem. Proc. (3)	5	Chem. Proc. (2)
Measurement and Analysis					
Balancing Machines	28	66	Metal Work. (22)	5	Metal Work. (3)
Capacitance	34	129	Metal Work. (23)	———	———
Color	27	59	Chem. Proc. (10)	21	Chem. Proc. (7)
Conductivity of Solutions	19	23	Chem. Proc. (11)	3	Chem. Proc. (2)
Electric Current		3	Metal Work. (3)	4	Metal Work. (3)
Curve Tracing	20	49	Metal Work. (14)	13	Metal Work. (5)
Density, Opacity	16	93	Metal Work. (9)	11	Chem. Proc. (7)
Dielectric Properties	15	51	Metal Work. (9)	5	Elec. Util. (2)
Frequency	27	323	Metal Work. (21)	5	Elec. Util. (2)
Flux	6	10	Metal Work. (5)	4	Metal Work. (3)
Gas Detection and Analysis	12	30	Chem. Proc. (6)	22	Chem. Proc. (10)
Geodetic, Geophysical, Meteor	6	1,016	Misc. Non-Mfg. (3)	6	Mining (3)
Impedance and Reactance	25	96	Metal Work. (18)	———	———
Light Intensity	16	64	Metal Work. (7)	———	———
Humidity	———	———	———	7	Food (2)
Noise	29	63	Metal Work. (22)	3	Metal Work. (2)
pH	86	203	Chem. Proc. (39)	17	Food (4)
Pressure	7	9	Metal Work. (4)	9	Metal Work. (5)
Reflection	5	11	Chem. Proc. (4)	———	———
Resistance	25	107	Metal Work. (15)	4	Const. (2)
Speed	63	151	Metal Work. (41)	12	Metal Work. (7)
Smoke Detection, Recording	25	44	Metal Work. (6)	3	Chem. Proc. (2)
Sound Level	30	63	Metal Work. (16)	6	Const. (6)
Strain	14	74	Metal Work. (13)	1	Metal Work. (1)
Telemetering	34	123	Elec. Util. (25)	24	Elec. Util. (15)
Thickness, Distance	9	19	Metal Work. (6)	12	Metal Work. (10)
Time	14	70	Metal Work. (9)	2	Misc. Mfg. (1)
Titration	22	29	Chem. Proc. (14)	9	Metal Work. (3)
Turbidity	10	11	Chem. Proc. (4)	4	———
Vacuum and Ionization Gages	13	286	Metal Work. (7)	———	———
Tube Testing	23	49	Metal Work. (13)	1	Metal Work. (1)
Voltage	81	407	Metal Work. (51)	5	Metal Work. (3)
Wave Form	33	122	Metal Work. (22)	2	Metal Work. (2)
Electron Microscope	9	11	Metal Work. (5)	3	Chem. Proc. (2)
Level	6	12	Chem. Proc. (3)	8	Chem. Proc. (4)
Moisture	15	52	Food (7)	5	Food (2)
Flow	———	———	———	11	Chem. Proc. (4)
Weight Measurement	18	53	Metal Work. (12)	25	Metal Work. (12)
Temp. Indication and Recording	29	252	Metal Work. (11)	14	Metal Work. (6)
Misc. Testing Equip.	25	90	Metal Work. (11)	3	———
High-Speed Photography	7	14	Metal Work. (4)	———	———
Hardness	2	8	Metal Work. (1)	5	Metal Work. (5)
Chemical	31	51	Chem. Proc. (16)	22	Chem. Proc. (8)
Vibration	25	50	Metal Work. (18)	8	Metal Work. (4)
Meter Testing	15	38	Elec. Util. (13)	3	Elec. Util. (3)
Quartz Crystal	6	265	Metal Work. (5)	2	Metal Work. (2)
Amplifiers	15	341	Metal Work. (10)	1	Metal Work. (1)
Oscillators	51	577	Metal Work. (41)	1	Metal Work. (1)
Oscillographs	72	312	Metal Work. (48)	2	Metal Work. (1)
Molecular Vibration					
Chemical Processing	———	———	———	14	Chem. Proc. (10)
Germ and Insect Killing	———	———	———	16	Food (10)
Supersonic Detection	———	———	———	11	Metal Work. (7)
Power Conversion					
Frequency Conversion	7	11	Metal Work. (4)	9	Metal Work. (5)
Inversion	4	36	Metal Work. (2)	6	———
Electro-Plating and Processing	9	68	Metal Work. (6)	8	Metal Work. (5)
Rectification	176	1,668	Metal Work. (67)	46	Metal Work. (10)
Regulation					
Generator Voltage	27	125	Elec. Util. (12)	44	Elec. Util. (26)
Skew	8	18	Tex. (7)	8	Chem. Proc. (3)
Speed Regulation	11	42	———	16	Metal Work. (8)
Slack Regulation	5	8	Chem. Proc. (4)	15	Metal Work. (4)
Voltage, Current, Phase	20	205	Metal Work. (10)	12	Elec. Util. (4)
Process Regulation	7	15	Chem. Proc. (2)	35	Chem. Proc. (13)
Safety					
Combustion	69	757	Metal Work. (30)	20	———
Fire and Smoke	4	6	Metal Work. (2)	8	Metal Work. (3)
Liquid Overflow	4	15	Chem. Proc. (4)	2	Mining (1)
Intrusion	25	62	Elec. Util. (13)	7	———
Lighting	3	6	Chem. Proc. (2)	10	Elec. Util. (3)
Machinery Stopping	32	286	Metal Work. (16)	44	Metal Work. (14)
Over and Under Voltage Alarms	9	218	Metal Work. (5)	5	Elec. Util. (2)
Fume Detection	6	15	Chem. Proc. (2)	6	———
Traffic	8	190	Const. (3)	13	Coal Min. (5)
Misc. Alarm	15	44	Chem. Proc. (5)	11	———

major divisions. To experienced electronic engineers some possible duplication between the sub-divisions beneath them will be apparent. It will be noted, for example, that the word "combustion" appears under "Control" and also under "Safety." Inasmuch as the data was largely obtained from men without specialized electronic knowledge it was necessary to tolerate such duplication.

The second column (*Number of Companies*), used intelligently, provides some measure of the relative importance of various types of electronic apparatus in industry at the present time. It will be seen, for instance, that users of tubes for rectification, under "Power Conversion", are, as might be expected, in the majority. On the other hand, the fact that users of tubes for temperature control are neck and neck numerically with those owning welding controls might come as something of a surprise. In this column, as in all other columns, the inclusion of percentages is deliberately avoided to discourage projection at least until the more voluminous report from which the figures are taken is thoroughly digested by the reader.

The third column (*Number of Devices*) provides a further measure of the relative importance of various electronic devices in industry, since the number of duplicate units in a plant as well as the suitability of a specific device for industrial use determines the potential market and, particularly, its "packaged" item possibilities. Note that rectifiers, temperature and welding controls are not only used in many plants but that they are purchased in considerable volume by these plants.

The fourth column (*Chief User*) is a useful key to the probable potential market. For purposes of compression here it has been necessary to show only the largest present user of each electronic device although in several instances other users were nearly on a par with them. It is desirable when attempting to evaluate the data in this column in terms of post-war potential that it be considered in conjunction with the data included in column six. It is also necessary to know that the industry classifications employed in this abstract are very broad indeed. The "Metal Working" industry classification, for example, embraces manufacturers of:

Iron and Steel Accessory Products
Non-Ferrous Accessory Products
Machinery (except Electrical)
Electrical Machinery and Equipment
Transportation Equipment (except Automobiles and Aircraft)
Automobiles and Automobile Equipment
Aircraft and Parts
Ordnance and Accessories (except Explosives)

So far we have dealt with data supplied by industries already using specific electronic equipment, under "Present Users." Now let's move over into the columns for which data was supplied by "Potential Users," people who may now use electronic equipment of some kind but lack it entirely for the specific uses under consideration.

Column five *(Number of Companies)* must obviously be studied in conjunction with columns two and three in order to speculate concerning the potential market. Similarly, column six *(Greatest Interest)* should be considered in conjunction with column five, and probably also in conjunction with columns two,three and four. Steady growth along lines already indicated by sale of equipment to present users appears to be a reasonable conclusion. Some shifts of interest will be noted but, in line with our introductory admonition relative to projections, conclusions relative to these must be left to the reader.

Potential Applications

Not the least interesting and instructive portion of the report are the many pages devoted to comment from men in industry who have unsolved problems and wonder if electronic equipment could solve them. While it is true that some of these problems might best be solved by other than electronic means, and while it is also true that some of them have already been solved by means of electronics, a few extracts should prove generally stimulating.

Typical remarks follow:

Metal Producing. "Photoelectric cells could be used to limit travel of furnace doors where high temperatures cause failures in existing limit switches, or could be used to open building doors for towmotors, or could be used to sound an alarm for pedestrians as crane hook is lowered down through hatchway."

"We should have some sort of temperature control and flame failure alarm in soaking pits and reheating furnaces."

"Our roll grinding machines, although of the latest design, could be greatly improved by supplying electronic control on the grinding wheel drive motor to maintain constant peripheral speed on the grinding surface of the wheel under varying feed of work and decreasing wheel diameter due to wear."

Metal Working. "In undercutting commutators on small motors, it is impossible to use an indexing arrangement to turn the commutator from mica to mica due to slight variations in the thickness of the mica and the copper, making the bar spacing non-uniform. We are working on an arrangement using the electric eye to position the mica by contrast of color between the copper and the mica."

"The many hundreds of individually motor-driven lens polishing machines which we use have very crude mechanisms for speed control. These might well be modernized by electronic motor speed control. A programming control on speed as the lenses are polished might be extremely valuable and greatly improve production."

"We need an electronic device to ring an alarm in case of a leak in our air conditioning system. Freon (refrigerant agent) is quite expensive and very hard to get. It has the property of turning the color of certain gases or chemicals. By having a photoelectric cell sensible to a certain degree, to the change of color of a chemical placed near the refrigerating coils, a leak could be easily detected, and an alarm given, or the cell would break the current to the compressors by means of relay. This device would save a large amount of money to industries using air conditioning."

Chemical Processing. "How about

gas analysis in the determination of the amount of isobutane in a mixture? Present method uses the infra-red spectrometer."

"Liquid level control of pressure vessels presents a problem when ordinary methods such as rotary stem packing glands and flexible discs are used. More development along the lines of a capacitive and inductive pickup type controller using a vacuum tube amplifier would eliminate hysteresis and sticking encountered in the mechanical type of controller."

"We have an operation involving the dipping of rubber-impregnated fabric into a solution containing an inflammable solvent. It is a continuous process, and static on the stock ignites the solution if the static eliminator fails. A collector connected to the sensitive grid of a tube should shut the machine down if static starts to accumulate."

Food Processing. "We need an electronic device to inspect our beverage bottles before filling and again after they are filled and capped. After the bottles are filled they are cased up manually and then pulled out of the case four at a time and inspected over a light. We need some sort of electric eye on the final inspection. Frequently when the operator is fatigued she or he will pass a dirty bottle after it is filled. We hope something electronic will protect us on this."

"Electronic measurement of dehydrator humidity levels to take the place of wet bulbs or hair hygrometers at dry bulb temperatures of above 200 deg F, where both the latter are inaccurate, would be useful."

"In a continuous vacuum pan operation on evaporated milk, we believe that if you had an electronic device that would measure the density of the milk and regulate the discharge pump and the milk intake that you would do the industry a great service. The operation at present is manual and most pan operators over-condense with a resulting waste of time and power. A device which would register the change in concentration of the milk in the pan that would be visible to the operator at all times is needed."

Textile Mills. "Warping, slashing, and weaving require careful regulation of slack yarn ends, so that a quality fabric will result from these operations. Proper tension throughout the various processes is one of the most important regulations confronting us."

"There are numerous points in the processing of cotton textiles at which package counters could be used, and we believe that a survey should be made of a large textile plant to ascertain the points at which such a device would be practical."

"An electronic device which would indicate breakage of warp or filling thread is needed for loom protection. Such a device would eliminate a considerable amount of mechanical motions. Also a device which would indicate an empty bobbin."

Public Utilities. "Use of voltage amplifier and thyratron trigger tube combination to replace electromechanical relaying schemes at present used on all power lines seems desirable. The idea is to standardize the unit and vary applications by variations in input networks and accessories, thus adapting to operation by voltage, current, frequency, power factor, etc., and assuring faster operation than afforded by conventional type relays, without the necessity of using carrier frequencies."

"Quicker and more accurate means of cable fault locating are needed and it is felt that there is a wide field of application for electronic cable fault locating equipment."

"We have a boiler that has an induced draft fan and a short smokestack. This fan is driven by a 2300-volt motor connected to fan by a hydraulic coupling. In the event of electric power interruption this fan stops and if the natural gas fuel is not cut off immediately, there is danger of improper combustion mixture with a resulting explosion. This is a 1000-hp boiler."

Coal Mining. "Control and signal for mine ventilating fans is needed. Where the air must not stop, someone should know at once if control of fan fails, or cave-in blocks the air's natural flow."

"Detection of poisonous methane and carbon monoxide gases in coal mines is not yet being well handled."

Other Mines. "Using hand labor at the present to make rip-rap. Sizes 25 to 150 lb, minimum of four inches thick in one dimension. Material weighs 165 lb per cubic foot and can be any shape or size between the weights and dimensions given. We would like to sort these sizes from material loaded from quarry face. Material will run from fines to four or five hundred pound rock."

"Detection of tramp iron and steel on ore belts."

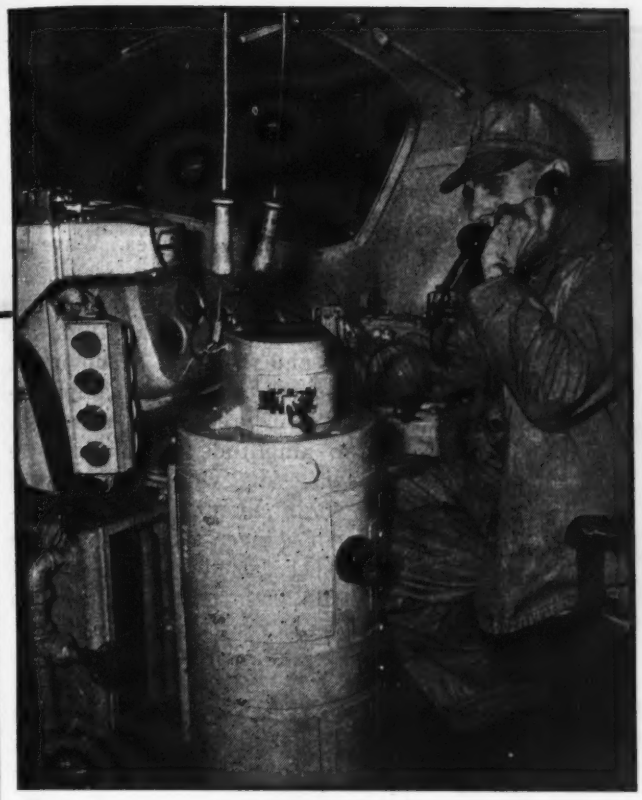
"Generator voltage regulation and excitation. Three widely scattered hydro-electric plants are operated in connection with mining operation. Power regulation is a problem, particularly in starting up large power consuming equipment."

Construction. "Analysis of soils, aggregates, asphalts and wetting agents to determine their electrochemical properties. Whether molecules are positively or negatively charged. This will enable us to make a more homogeneous and compatible mixture of the materials for road pavements. We are in a research program at this time involving this problem and are in dire need of a method of determining the properties of these and other materials such as paint, steel, cement, etc."

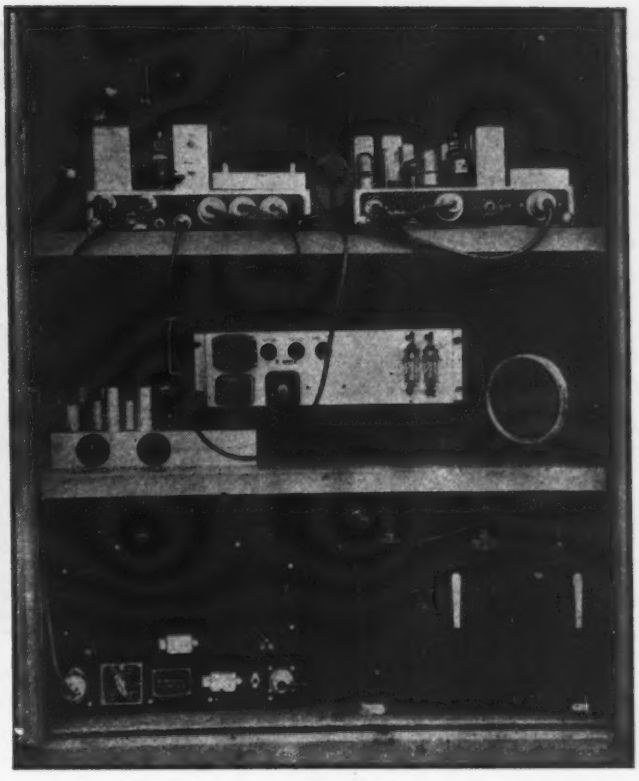
"Chlorine residual determinations in municipal water supplies, including control at plant and portable instrument for accurate determinations at various points in the field, are needed."

"An electronic device to measure humidity is badly needed. Evaporation from large reservoirs, especially in the arid West, will become a more important factor in operation than it now is. A device that will permit evaluation of evaporation from water surfaces, from snow surfaces and, for that matter, from land surfaces undergoing application of water, is greatly needed. If possible, it should be so arranged as to measure water content of the air specifically or afford a comparison from, or with, unaffected surfaces nearby."

For further details relative to the gear in use and wanted by the 796 companies encompassed in the survey the reader is referred to the report.—W. MAC D.



Freight engineer using a radiophone in the cab of a diesel locomotive

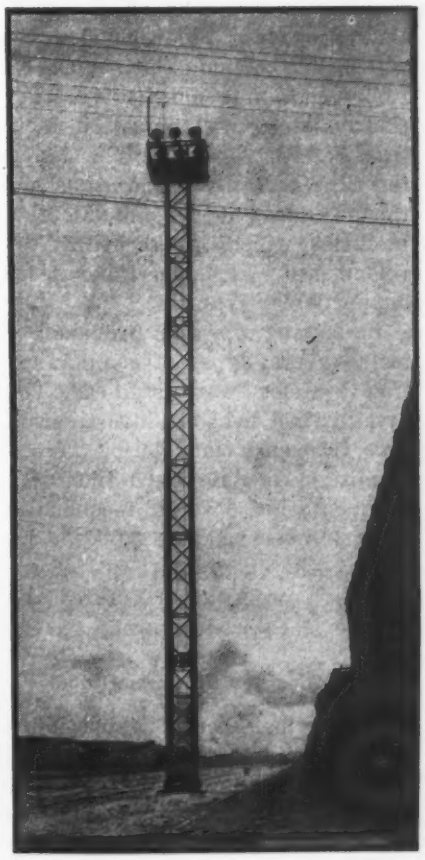


Motorola and Mallory equipment installed at the base of a lighting tower in a yard, comprising a fixed radio station

of six g's (193 ft/sec/sec) was encountered on a train moving at seven miles per hour when brakes were applied. There is an average slack of four to five inches between each car. When a hundred-car freight train starts up there may be slack of as much as 40 feet taken up before the caboose is finally moved ahead. By the time the engine has taken up all of the slack it may have attained a velocity of two miles per hour, or three feet per second. The caboose will be required to change its velocity instantly from zero to two miles per hour. Thus all the receivers and transmitters must be shock-mounted in two directions, up and down to prevent bouncing and front-to-rear to minimize shocks of starting and stopping.

Another problem in setting up a system of railroad radio communication involves choice of the most suitable power supply. The power supply must be capable of operating a receiver and transmitter on locomotives, cabooses, and at fixed stations. Most railroads have 64-volt d-c power available in their diesel locomotives. A 25-volt d-c power supply is usually available in steam locomotives, but as yet no power supply is ordinarily provided in the caboose. If d-c dynamotors are used for power conversion, two units are required—a low-voltage unit for tube filaments and a high-voltage unit for plate supply. If radio units are designed to operate from a-c power, then only one device with a rotatable armature is necessary to convert from d-c power to a-c power. This seemed the logical answer in our case to the problem of power supply on locomotives.

On steam locomotives the steam power is directly available. A turbine connected directly to an alternator was used to provide power. With mechanical steam regulation, 117-volt, 60-cycle a-c power was obtained with regulation better than 1 percent. On cabooses, a 12-volt generator charging a 300 ampere-hour battery supplied power to a rotating machine that delivered a-c power. The use of a-c power throughout means that all transmitters and receivers are directly interchangeable with one another on either steam or diesel units. This



A typical fixed installation in a yard, showing antennas at the top of a lighting tower and the compartment containing transmitter and receiver at the base

ROCK ISLAND RAILROAD

Radio Tests

Communications problems peculiar to railroading, such as the necessity for equipment design capable of withstanding unusual vibration and shock and capable of operating from a variety of power supplies, are analyzed on the basis of seven years of experiment. Signal-to-noise ratios on 40, 118, 150 and between 2000 and 3000 Mc are charted

By ERNEST DAHL

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THE DEVELOPMENT of railroad radio has progressed rapidly in the last year. Many articles have been published on the utilization of radio by railroads, but little has been published on recent technical advances in the art. It is the purpose of this article to record the research and operating experience of one railroad in developing its own radio system of communications.

In the near future, radio seems destined to play an important part in the progress of American railroads. Although intensive research for the development of radio facilities has been under way for only a short period of time, important possibilities have already been uncovered. For example, radio makes possible two-way communication between: (1) both ends of a train, (2) yards and trains, engines, or cabooses, (3) different yards and stations, (4) wayside stations and trains, engines and cabooses, (5) different trains, en route or in yards and stations, and (6) brakeman and flagmen.

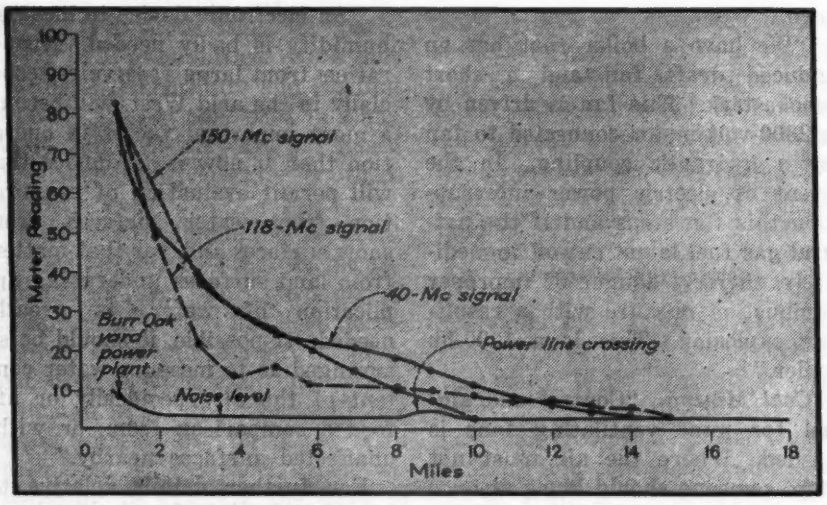

FIG. 1—Curves showing signal-to-noise ratios on three different test frequencies, recorded as a train carrying the Rock Island Railroad's radio test caboose rolled away from the yard at Blue Island, Illinois. Transmitter power employed was 10 watts output in all three cases

While radio will merely provide supplementary communication facilities in some of these cases, it serves to increase safety, to speed freight and passenger traffic, and to provide effective communication in the event of storms, floods or other emergencies. In other cases, particularly when trains are in motion, radio provides the only form of communication which is feasible. The need for railroad radio communication has greatly increased with extensive war-time use of 100 and 150-car trains.

Vibration Mounts and Power Supplies

Considering the rapid advances which have been made in mobile radio communication systems within the past decade, it might be presumed that commercially available equipment built for other purposes could be applied directly to railroad use. Such a procedure has not been found to be entirely feasible, however, because of a number of unusual requirements. The problems of shock and vibration, of appropriate power supply, and of determining suitable operating frequencies and methods of modulation must all be considered in developing a satisfactory system of communication for railroad use.

In actual railroad service, all units must be capable of withstanding terrific shocks. Measurements made on a caboose of the Rock Island Railroad showed that a deceleration

Mc. In each case a quarter-wave antenna was used. In these measurements only carrier radiation strength was measured at a given distance and used as a basis for comparison.

Experimental Signal-to-Noise Investigations

A mobile field laboratory was set up for making all signal strength measurements for yard operation and front-to-rear service, for checking apparatus, for measuring shock, and for developing appropriate power supplies. This unit consisted of an all-steel caboose, equipped with a gasoline power supply. A gasoline-driven 1000-volt a-c generator was mounted on the roof, and a battery-operated charging generator was installed. The communication equipment was operated from the battery supply, while all test equipment, fluorescent lighting and auxiliary gear was run from the a-c generator.

The caboose was equipped with a complete work bench, standard frequency source, and receivers for calibrating from WWV standard frequencies. Most measurements were made continually over territory served by the Rock Island Lines, including Chicago to Kansas City and Kansas City to Denver, and in connection with the Denver and Rio Grande Railway through mountainous area and through the Moffat Tunnel. For the first time in the history of the Rio Grande, radio communication worked through the six-mile-long Moffat Tunnel. High-frequency tests indicated that the tunnel had a waveguide effect. The signal from the caboose had no trouble in reaching the locomotive, or inversely, if the engine was outside and the caboose inside.

An Esterline-Angus recording meter was set up for obtaining a permanent record of noise versus signal strength. The system set up to do this was as follows: At the frequency to be investigated, noise measurements were made in a complete run over the railroad route. Next, a complete run was made with the transmitter on 100 percent of the time, making continuous measurements of the output of the receiver limiter. This gave the signal strength throughout all parts of the route covered. The ratio of the first to the second set of measurements yielded the signal-to-noise ratio over the entire route.

Direct comparisons of noise and signal were made at a number of frequencies on this basis. Results at some of the lower frequencies are shown in Fig. 1. Figure 2 shows results between 2,000 and 3,000 Mc. The very much larger signal-to-noise ratio obtainable there made it possible to obtain satisfactory communication with lower power fed into the antenna and indicated the desirability of a swing to the microwave frequencies.

Details of Equipment

The first project under development was the establishment of a yard communication system enabling the yardmaster to communicate with either the yard foreman or the engineer on a locomotive. The need for this becomes very apparent when it is realized that a switching locomotive may travel 10 to 20 miles to pick up cars from another yard, the stockyards, or a fruit terminal, and haul them into our yards. Some actual uses of the equipment during the tests are shown in a chart included here.

One master station was installed for this kind of service. This station was set up with a receiver and transmitter at the base of a lighting tower. A coaxial type antenna at the top of the tower was connected to the transmitter and receiver by means of a coaxial cable. In this system the receiver and transmitter combination can be controlled from various points in the yard or from remote stations. The yardmaster or yard superintendent can call any locomotive working in or within the neighborhood of that yard.

In actual operation, the locomotive number was used to identify each locomotive, such as Diesel 700 and Engine 2103. When the engine is in some other yard, a call may be put through for some special car, or to add cars to trains in this yard, thereby saving a full trip or a return trip in order to pick up the extra cars. If for any reason the engineer is not clear on instructions, on what cars to pick up, or

TYPICAL RAILROAD RADIO USES

ENGINE TO CABOOSE

Purpose	Est. Time Saved (min.)	Comments by Conductor
Checking air line four times during day	40	Air was set and released by use of radio
Hot box	20	Train stopped within five minutes after receiving signal. Car set out and train moving after 25-minute delay
Clearing East Main for 504	15	Backed 127-car train across to West Main
Hot box	15	Received signal at Rockdale and informed engine crew to stop at Joliet for necessary repacking
Talk to engineer	15	Try air, tell engine no. cars in train, tons
Talk to engineer	25	Advise head end to set out hot box at Columbus Jct.
Set out bad order car	30	Car set out and bill left at Trenton
For air test and high-balling	60	One hour saved between Trenton and Kansas City
High-ball from Blue Island	——	Only way of knowing rear of train was coming
Talk to engineer	15	Tell engineer 9 had us cut out so could not pick up train order at depot. Would have been necessary to stop train
Hot box in middle of train	——	Would have been necessary to pull the air and break train in two
Test air and high-ball	20	Kept in close connection with front end
Emergency air-brake setting	25	——
Talk to engineer	5	Let head end know rear brakeman was on
Hot box	15	——
Set out car behind 80 cars. Each move made with radio because of curvature of track	15	Used radio at various times to converse with engineer regarding movement of train
Test air and high-ball to leave town	10	Amount of time used by carmen making this air test
Have train pull over insulated joints to clear blocks	15	Saved walking 84 cars to tell head end to pull up
Pull up so 11 could get in clear behind 93	15	Saved walking 84 cars to tell head end to pull up
To get speed of train up hill	——	After leaving siding top speed up hill was 32 mph.
Talk to engineer	——	Checking speed of train
Talking to head end testing air and high-balling	30	Used for high-balling after slow orders and in regard to train movement
Setting out 8 cars	30	——
Setting out 44 cars	20	Testing air and high-balling
Talking to BI yard office	——	Found out what track to use
Talk to head end	10	Give engineer number loads, empties and tons in train & OK departure
Talk to head end	——	Give OK to proceed after passing over slow order
Hot box rear car; give instructions move slowly due to bad condition	30	Saved walk of 122 cars to give instructions as to speed and where to dispose of car. Also avoided setting air from rear end
Instruct engineer when to stop and have switch engine take rear car off train. Also give OK to proceed	20	Rear car in train taken off by switch engine at Joliet. Burr Oak Yard notified to have switch engine waiting at Joliet

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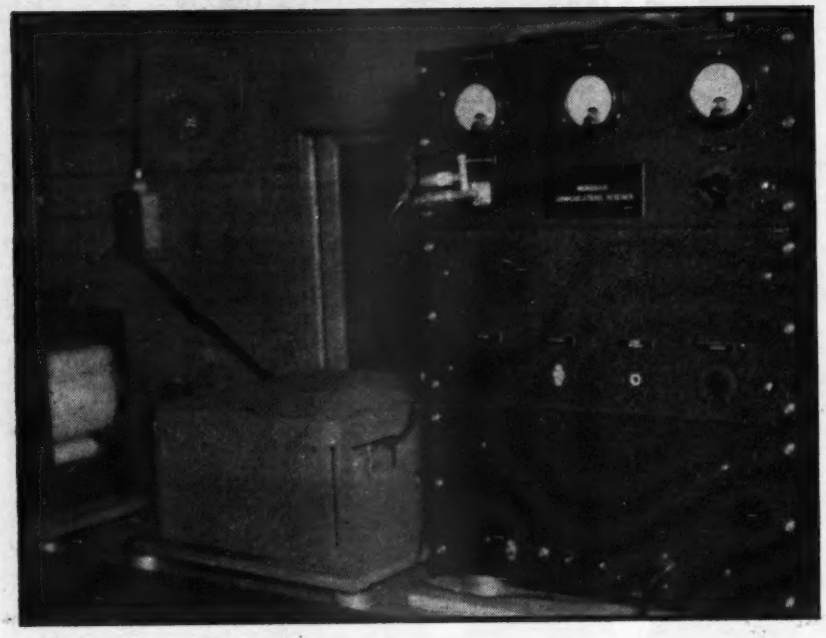


Experimental 2000-3000 Mc radio receiver using a Klystron oscillator. The Esterline-Angus recorder used to check signal-to-noise levels may be seen at the left

makes for extreme flexibility.

Late in 1937 we set out on a program of planned progress, and the road's recent studies of radio communication on trains is a part of that program. This included the setting up of an Electronic Section whose first job was to study the available communication facilities and the possibility of adapting these to railroad operation, and the design of new communication facilities which would utilize developments which had taken place during World War II.

In setting up this program of tests, several types of communication systems were studied. The first distinct field for investigation was frequency modulation versus amplitude modulation. Since experimentation covered frequencies from 40 megacycles to 3,000 megacycles, other characteristics of radio wave propagation entered the picture in the comparison.

Modulation and Frequency Studies

The normal factors which influenced our choice of frequency modulation over amplitude modulation were: (1) the advantage of frequency modulation over amplitude modulation in the elimination of noise, because of the characteristics of the limiter tube, (2) freedom from interference with f-m as compared to a-m, and (3) the constancy of audio output so long as the frequency deviation is constant, whereas with amplitude modulation the amplitude decreases with the distance from the source of the signal. The last-mentioned factor was a particularly important one, since on the basis of noise reduction alone the advantage of frequency modulation over amplitude modulation might not have been decisive where both types of service were tried at high frequencies at which noise is minimized.

As the frequency is increased and wavelengths become shorter, buildings, towers and natural obstacles tend to reduce the amplitude of the signal. Moreover, microwave signals may be received over two different paths so that the resultant received signal varies in amplitude according to the relative phases of the two waves. Wave reflections and standing waves increase amplitude variations. Now, if such changes in amplitude are present and the train is moving at a reasonable speed, the amplitude changes will produce an effect similar to amplitude modulation, the frequency of which will depend upon the number of nodes or antinodes in a given distance, and the train speed. This modulating effect will hereafter be referred to as the flutter effect. The flutter effect became more and more pronounced as the carrier frequency was raised. At 40 megacycles it was barely audible, at 157 megacycles it was very pronounced, and between 2,000 and 3,000 Mc satisfactory communication was impossible with amplitude modulation while the train was in motion. When using frequency modulation, signals were sufficiently strong (even over the greatest distances for which communication was required) to saturate the receiver limiter and the flutter had no effect on the audio output.

The actual operating frequency chosen was to be determined by investigation. Measurements were made at 40 megacycles, 55 megacycles, 157 megacycles, 300 megacycles, and between 2,000 and 3,000

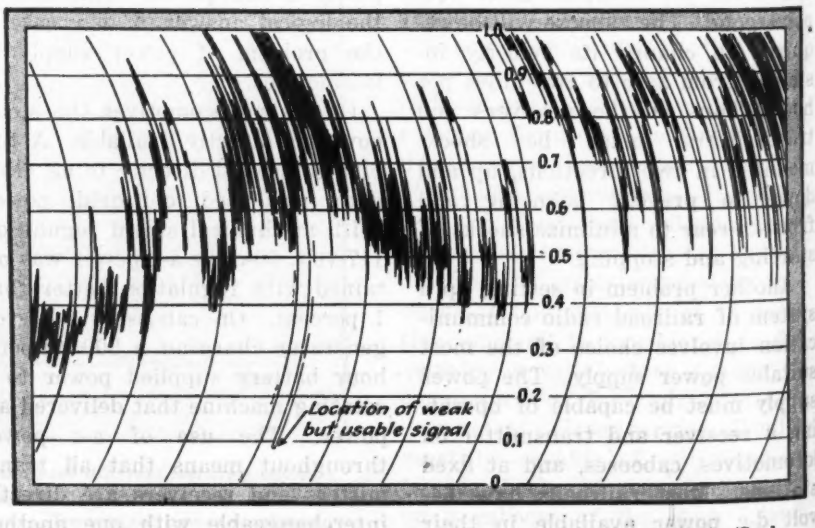


FIG. 2—Recording showing typical signal-to-noise ratio on 2000-3000 Mc (Scale shown on chart gives arbitrary values)

(*Continued from preceding page*)

Purpose	Est. Time Saved (min.)	Comments by Conductor
Talk to head end	——	Find out why stop was made for red block
Test air	5	Save pulling out drawbars and braking knuckle, won't have to set air from rear end
Let engineer know when train was over slow track	5	Radio is a time-saver getting over slow tracks and heading out of passing track
Let Engineer know switch closed and brakeman on	6	The fuses we can save to give signal on a long train will pay for a radio
Notify head end to set and release air and train ready to proceed	10	This saved time as there was no mistake in signals
Hot box	10	Would have had to set air from rear end
To advise head end when train was in clear	——	This avoided stopping when train was not in clear
To get signal to engineer that flagman was on	——	Could not have signalled head end if no radio
Talk to engineer	——	Told engineer I was going back to ask dispatcher about 91 which was delayed at Letts
Hot box	25	Engineer called to tell me what was wrong, saved walking 116 cars
Talk to engineer	5	Engineer called when they set out and were ready to go, and if flagman was on and ready to go
Air test	10	
Clear passing track for 98	20	Not only used radio for our train but gave signals to 98 to let him know when he cleared the main
Air test	10	Had 100 cars, difficult to see hand signals that far with a background of city lights
Get train in clear on passing track	——	Track wasn't long enough to get in clear. Dispatcher held train back of first signal at Allerton to run 18 against Ex. 97 Clio to Allerton
Hot box	40	Hot box 69 cars behind engine. Called engineer, had him cut engine off and come to rear end of train
Let engineer know when rear end train made up and test air	——	——
Talk to engineer	15	Had slued truck on head car. Instructed head end what to do with car
Converse with head brakeman to set out head car with slued truck	15	Saves lots of time if you have to instruct head end about a bad order car
Let engineer know when flagman was on	5	——
Hot box	20	Would have had to set air from rear end as I had 101 cars and could not get signal to head end. Might have got draw bar or knuckle and caused big delay
Air test	10	140 cars, half of train around curve
Talk to engineer	10	In passing through passing track instructed engineer re closing switch, etc.
Air went into emergency	25	Burst air hose behind 137 cars. Could not see signals
Talk to engineer	20	Head end missed order. Called to find out if rear end got it. Made contents known to head end. Saved stop
Talk to head end	20	Talked to head end about block and crossing at Polo
Talk to head end	——	Talked to head end account hot wheels
Talk to head end	——	Head end stopped to inspect hot box rear end. In 3 min. had train off main road

YARD TO ENGINE

Purpose	Comments by Yard Master
Test	——
Detail on movement through plant, lead to shor t 1, call tower on phone	——
Called account move on So. Chicago caboose at north end yard	——
Lined up 700 on some work	Changed work on 700
Had 700 come up out of yard—to couple up track 14 to be ready for eng. 2557, to take off on Hill I. H. B. Spec., due on Hill 3:00 A	——
To make change in work and put 700 engine and crew into lunch	——
700 called to find out where to put cars	——
Instruct crew on added work	——
700 called to secure disposition on two cars not carded	——
Lined up crew on work	——
Test	——
Instruct crew	No way to contact except by radio
Change work	Could not get switch tender
Instruct crew	——
Change work on yard	——
Instruct crew	No way to contact
Line up crew on work in yard	Diesel at north end of yard. Could not get switch tender
Instruct crew on work	——
Had two R.C. cars for B.O.C.T., these cars were delivered, and Rettker, with Engine 2103 had the bills out of X5 for these cars. Made this call to have him deliver t he bills to B.O.C.T.	——
Called engine 2103 at 12th St. Yard, to make test	——
Line 700 up with new work	——
Instruct crew on take off 96	No contact, only through tower
Instruct crew	Could not contact except through tower. 700 called to instruct crew on work
Line up crew	——
700 called about car	Car in train 700 switching. No card on car. In on road train. 700 called for information on car
Lined crew up to do some extra work	——
Called to line up crew on work, later cancelled call	Normal contact would be on phone through Gresham Tower. Probably could not contact crew for an hour or more

has any questions concerning instructions on pick-up or perishability of freight, he can call the yardmaster to get complete instructions on handling this project.

In this service, direct comparisons were made between apparatus operating on various frequencies. At all frequencies the service area was covered equally well, but atmospheric noise was lower at 157 megacycles, and had disappeared completely between 2,000 and 3,000 Mc. A slight flutter effect was noticed on 157 megacycles when amplitude modulation equipment was used. The maximum a-c power input was 300 watts. The radio-frequency power output of the final stage was 10 watts. Satsifactory communication was obtained for a radius of 15 miles from a central point.

In front-to-rear train communication the equipment is used by the conductor and the engineer. Under present operating rules the conductor is in charge of the train movements at all times and must initiate any instructions as to starting and stopping of trains, the handling of hot boxes, or relating to any emergencies which might develop. In the actual operation of this equipment, the conductor can save a considerable amount of time in the handling of a train, as indicated by the chart, which shows typical actual equipment uses.

Without front-to-rear communication the conductor must stop the train from the rear. This means that the brakes on the caboose go on immediately, on the next car a short time later, and so on. When such an occasion arises the engine keeps pulling after the caboose has stopped, resulting in flat wheels or breaking a train in two, which may result in a derailment, personal injury, or serious delay. On the other hand, when the conductor can talk to the engineer in the locomotive, he can tell the engineer to apply his brakes immediately and the train will stop normally from the front end. Also, in starting a train the car brakes must be pumped up and checked for operation. This is called checking the air. This can be accomplished in less time when the conductor can report the air pressure back to the engineer and then give him the high-ball to get

out all the air. In yards and on switchings, he can inform the engineer when the train is in a safe position, i.e., when the last car is on a siding of the main line. All these problems have been intensified recently with the advent of 100 and 150-car trains.

For front-to-rear communication service, comparisons were made between signals at various frequencies. As in other cases, all units worked satisfactorily, with atmospheric noise present on 40 megacycles, less on 157 megacycles, and disappearing between 2000 and 3000 Mc. A flutter effect was audible on 157 megacycles when going through towns or areas with high buildings or water tanks.

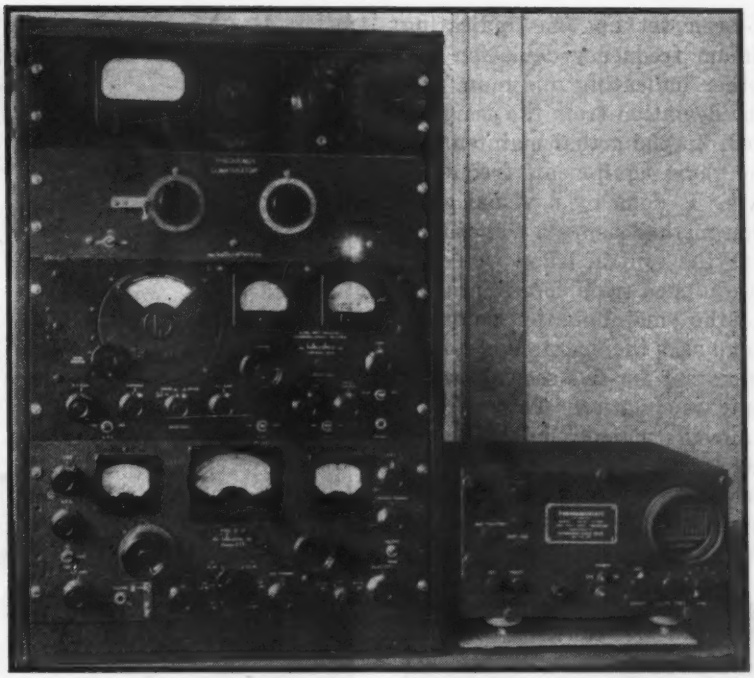
In order to make patterns of the radiation from antennas located on various portions of locomotives, two diesel locomotives and one steam locomotive were equipped with quarter-wave antennas and mounted at various locations on each of the locomotives. The locomotives were then driven on a turntable and the carriers turned on. A receiver was set up about 100 feet away and the turntable rotated through 360 degrees. From the results obtained, information was compiled which indicated that for the best radiation pattern the antenna should be mounted in the center of the cab roof.

Microwave Tests

Tests on 2000-3000 Mc were conducted between Chicago as one terminus and Salt Lake City, Denver and Kansas City as the other. Included in these tests were applications of radio communication to all the various forms of railroad operation. It is believed that the 2000-3000 Mc equipment is still sufficiently novel to warrant a brief description.

An antenna, fed by a 10-watt crystal-controlled transmitter, was placed on the locomotive; a stub-supported line was used to connect the antenna and the transmitter in the locomotive. The receiver was located in the caboose and was connected by means of the stub-supported line to the receiving antenna.

A Klystron local oscillator was used to beat against the incoming signal and both signals were fed to a crystal-type detector or mixer. The intermediate-frequency output was then fed to the i-f channel, as in the usual superheterodyne receiver. The limiter current in the superheterodyne was measured by means of an Esterline-Angus recording meter, which made a direct comparison between the noise and the signal received at any given point.



Panoramic and Hallicrafters equipment used to visually check the frequency of transmitters as trains using them pull into the yard. A block diagram of the setup is shown in Fig. 3

Very interesting results were obtained. While the train was motionless the signal was constant. As the train moved the signal would increase and decrease just as if it were actually passing through waves of energy. The operation of this system, using very low power, was excellent.

Service and Maintenance

The installation and maintenance of equipment becomes quite a problem in railroad operation. It has been found expedient to divide the work into two categories and between two organizations. The installation work, involving power supplies, power switches, and generators on locomotives, is all done by the electricians' group. The installation of telephones and radio equipment, and tuning and adjusting of the sets, is done by the communication department.

Two sets of frequency standards

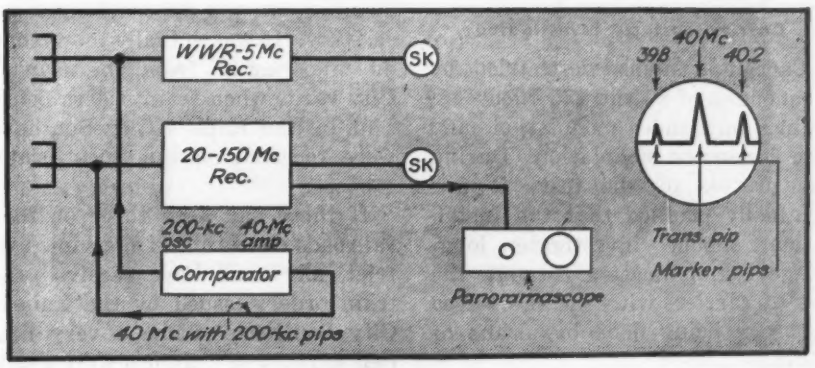
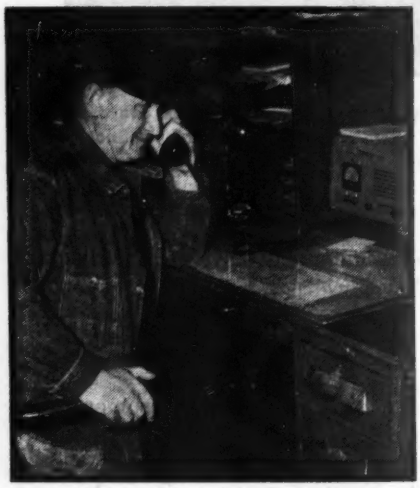


FIG. 3—Block-diagram showing system used for visual frequency checks

have been set up, one indicating maximum frequency deviation and the other indicating minimum frequency deviation from the assigned carrier. In the actual maintenance of the radio equipment, frequency checking is done by a visual comparison method using a Panoramic unit at the central office. As each radio-equipped train comes into the yard, the maintenance engineer calls and asks the operator to transmit a carrier for five seconds without any modulation. This carrier then appears visually on the screen of the Panoramic between the two peaks designating limits of frequency deviation. If the carrier is



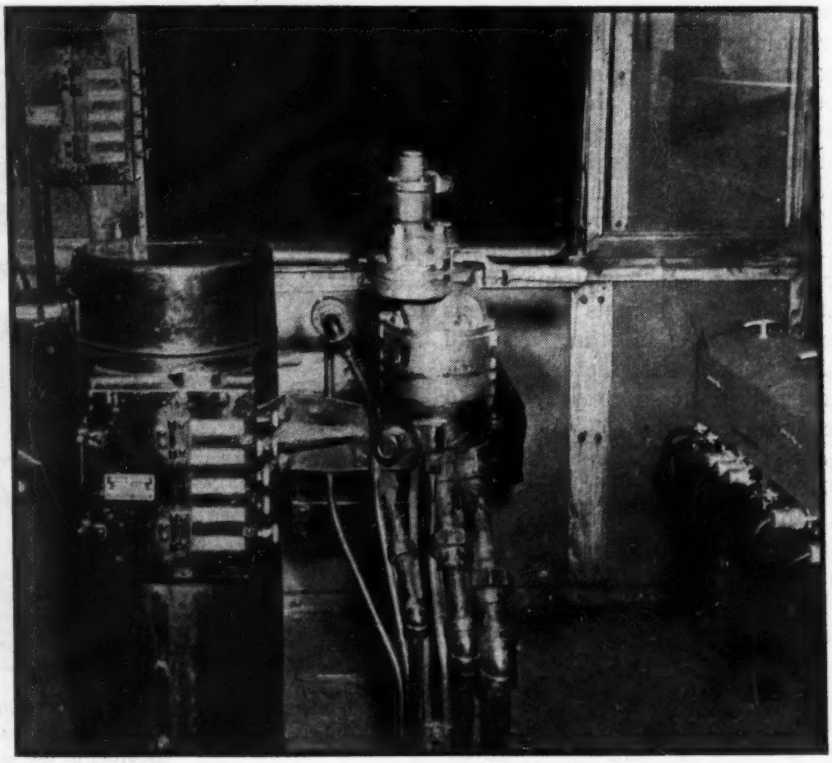
Remote control position for a typical yard station

outside the peaks, the equipment is removed from service and brought into the shop for frequency checking. The visual system has advantages over taking meter readings because of its simplicity and the speed with which a large number of remote units can be checked. This system is illustrated in Figure 3.

Carrier Systems Investigated

Carrier systems were tried on frequencies of 80 and 175 kilocycles, using amplitude modulation and also frequency modulation. During the process of the tests it was originally planned that the installation should investigate long-range communication through the use of carrier, with the short-area coverage being done by means of radio.

Space radio was to be used for yard systems and terminal operation where no wayside wires were within a relatively short distance of the locomotive or caboose, as when yards were a mile or two miles wide and five or six miles long. It was assumed that radio signals broadcast in all directions from a certain point would easily cover two or three yards working in the same locale, with no worry about proximity to wires.



Frequency-modulated equipment, installed in the cab of a locomotive, can be seen at the right

Further investigation late in 1944 proved that although carrier systems were excellent for long-distance transmission, the problem of interference with other railroads also using carrier systems appeared. To cite an example: A 120-car freight equipped with the carrier system was approaching Kansas City. It was actually more than 40 miles away from the Kansas City yards when train orders being sent by the Kansas City Southern were received on the Rock Island caboose.

If there had been three or four railroads operating in the same district, all would have received the train orders issued by the Kansas City Southern. Since a very limited number of channels were available it was believed best, therefore, to drop the induction system in favor of a complete space radio system in which directional antennas would tend to guide radiation along the bounds of the railroad. Another important advantage appeared in favor of space radio. If wires were down or had more than two or three breaks, an induction system would be out of service. The space radio system would still have its normal operating characteristics, and would be relatively little affected by sleet storms, floods and similar emergencies.

Conclusions

As a conclusion to the various tests made by the Rock Island Railroad, it would definitely seem from the results we have secured that (a) the space radio system is preferred, and that (b) frequency modulation, (c) low power, and (d) directive high-gain antennas are all in line for further development for railroad communication.

The use of safety devices working on a pulse or radiated wave pattern will surely find a way into railroad warning systems. At the present time we are building several experimental units using high-frequency radiation for warning systems.

Orbital-Beam U-H-F TUBES

Output frequencies as high as 500 Mc can be varied continuously or shifted back and forth between two or more values by applying appropriate keying signals to electrostatic deflecting plates, so as to vary the transit time between control grid and plate

By R. M. SMITH *Camden Forge Co. Camden, N. J.*

FEW conventionally designed electron tubes will operate with any efficiency above 100 megacycles and fewer still at frequencies of 500 Mc and higher. However, this is not to say that successful operation is not obtainable in the ultra-high-frequency band (300 to 3,000 Mc) with conventional tube construction, because there do exist some new types of tubes which have been designed especially for such frequencies. These tubes are not generally spoken of as being conventional, however, at this stage of the game.

The writer had occasion to assist in the development of a secondary emission type tube especially designed for use at 500 megacycles or lower. The tubes had the appearance of an overgrown acorn tube. From the laboratory work a number of unique characteristics were found which suggested some new uses and advantages offered by this kind of tube.

Ultrahigh-Frequency Problems

Aside from the problem of efficiently driving the input control grid at ultrahigh frequencies to put the useful signal onto the grid element where it has control on the amount of electrons passed on to the anode, there are a number of other problems arising from within the tube itself. Among these are the limitations imposed by the electron transit time. Electron travel time from the cathode to the control grid constitutes one source of trouble and the result of this is a loading effect causing poor power factor for the input driving circuits. With extremely close spacing between the cathode and control grid and with high electron velocities this loading effect can be reduced to workable values where tubes of the acorn variety are used.

The characteristics which we are to discuss herein, however, are those imparted by the flight time of the electrons after they leave the control grid and until they strike

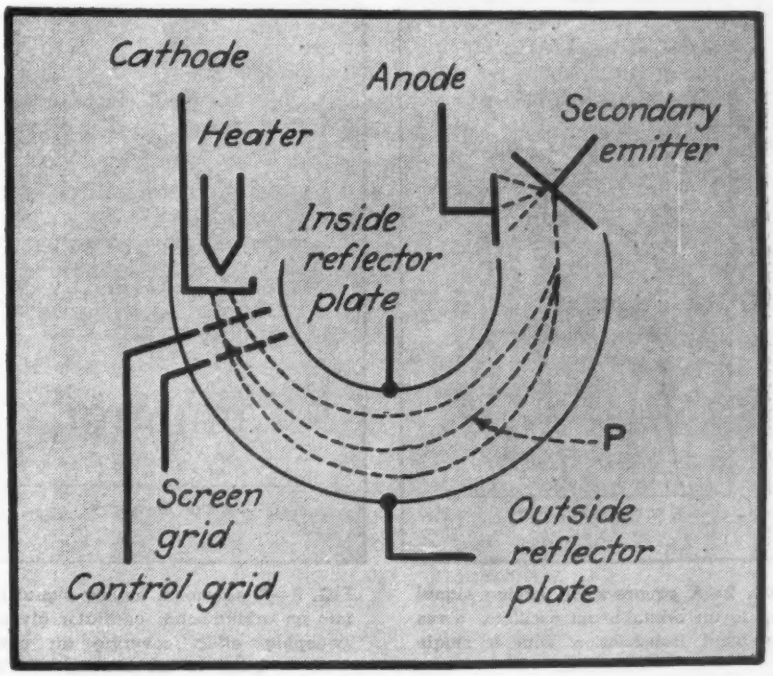


FIG. 1—Basic electrode arrangement in an orbital-beam tube

the anode or, in this particular case, the secondary emitter. This flight time, if appreciable compared to the interval of time represented by one cycle of the operating frequency, very definitely has control over the operation of the device.

Grid-Anode Transit Time

In view of this consideration the electron transit time was made approximately equal to the time of one cycle of the operating frequency, so as to have a synchronous or in-phase relation. It was found that this in-phase relation does exist and that if the transit time was made to vary, a corresponding shift in frequency response or a reactive effect on the external circuits was observed. Thus we can say that a change in the electron transit time has a corresponding reactive effect, the sign of which being determined by the direction of the change in time relative to the carrier frequency. These reactive influences were utilized as a means of control over the tube and its associated circuits.

Although a secondary emission type was used for the experimental work, the principles of control by transit time variation would apply in triodes and similar tubes where the electrons are collected by the anode, bearing in mind that the physical design must allow for the control of the electron transit time in the manner described. A triode oscillator circuit is generally preferred for simplicity. Since we were interested mostly in receiver circuits with high gains per stage, the secondary emitter tube was used because of its inherent high mutual conductance. As a power amplifier this tube was found advantageous, as will be pointed out later.

Principle of Orbital-Beam Tube

The essential elements of the first orbital-beam tube are shown in Fig. 1, and include a heater, cathode, control grid, screen grid, inside reflector plate, outside reflector plate, secondary emitter, and anode. If we were to visualize the flight of a single electron, for example, we find that after its emission from the cathode, attraction by the positively connected screen grid provides it with an initial velocity sufficient to carry it through the screen grid, beyond which the higher potentials applied to the various other elements speed it along some curved path, say *P*, to the secondary emitter where its collision with the activated plate causes the radiation of secondary electrons, some of which strike the anode.

The velocity of the electron during this flight remains substantially constant as determined by the static potentials applied to the various elements, and its path has been made purposely circular. The circular path permits lengthening or shortening of the flight path, thereby causing more or less time to be required by the electron in traveling from the control grid to the secondary emitter. The normal direct voltages applied to the various elements are approximately as follows: screen grid—150 v, inside reflector plate—150 v, and outside reflector plate—200 v. To lengthen the path a greater d-c potential is applied to the outside reflector or less to the inside reflector. The electron having an initial velocity and potential as determined by the screen grid is either attracted toward a higher-potential field or repelled by a lower one, so that it is effectively guided along the curved course by the curved electrostatic field existing between the two reflecting plates. In other words, by adjusting the d-c potentials applied to the reflecting plates the mean diameter of the circular flight path taken by the electron is caused to vary more or less. This control effect is the nucleus of the characteristics utilized in this conception. The principle of electron stream deflection is similar to that employed in other applications such as the cathode-ray oscilloscope, beam tubes and others.

Pulling Effect

If the tube and its connected circuits were made to oscillate at a frequency corresponding to the order of time taken by the electron in its traveled path, it was found that by varying the length of the electron flight path and consequently the time taken, considerable reaction or pulling effect was reflected upon the circuit, resulting in a change of operating frequency. The degree of control made possible is appreciable. By way of example, the particular tubes which were used gave a response variation amounting to ±0.5 percent at

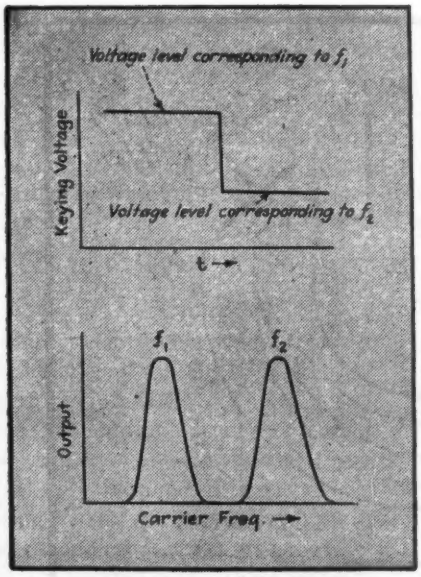


FIG. 2—A square-wave keying signal fed to an orbital-beam oscillator gives two-band transmission with a single transmitter

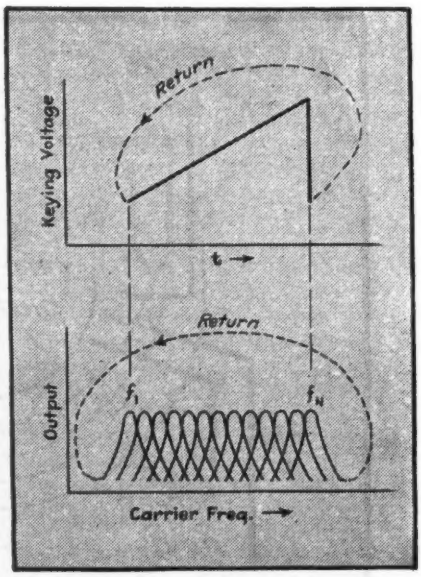


FIG. 3—A saw-tooth keying signal fed into an orbital-beam oscillator gives a sweeping effect covering an entire band of frequencies

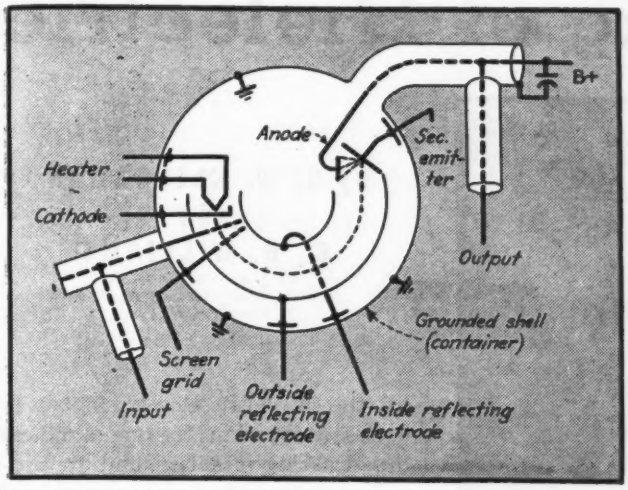


FIG. 4—Single-ended operation of an orbital-beam tube acting as an amplifier

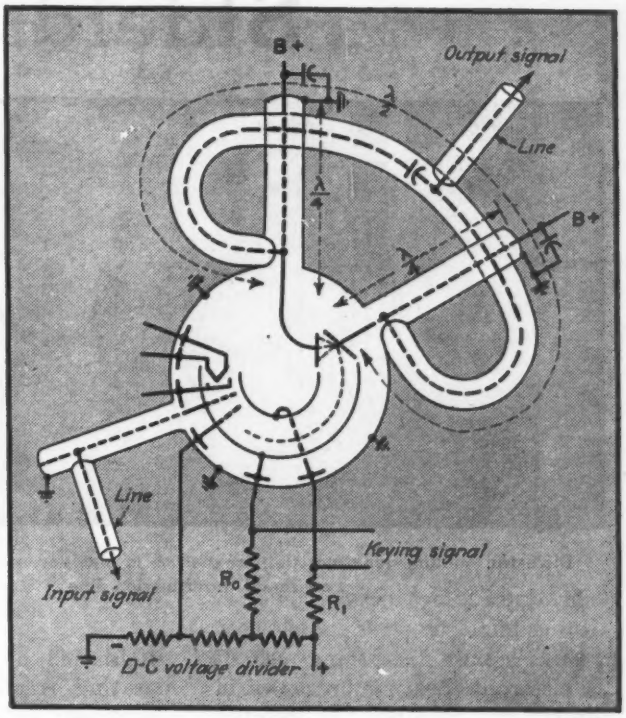


FIG. 5 (at right)—Use of a coaxial resonant line with an orbital-beam tube to secure push-pull amplification

500 megacycles before any reduction in oscillation strength took place. This frequency change was obtained by a 2-percent variation of the d-c potential applied to either reflecting plate.

It can be shown that the above phenomenon can be reduced to capacitive or inductive reaction effects and thus utilized for a number of circuit functions such as circuit compensation, oscillator stability and frequency response change, regeneration control, multiple-band and wide-band reception.

Possible Applications

These considerations immediately suggest the possibility of applying modulation signals to the reflecting plates for obtaining the following modes of operation: sine-wave modulation for communication and other uses; square-wave keying signals to obtain two or more distinct operating conditions, such as multiple-band reception or transmission (see Fig. 2), and saw-tooth keying signals to obtain a sweeping effect covering a continuous band of frequencies (see Fig. 3).

An orbital-beam tube is normally used in single-ended fashion as shown in Fig. 4, where the output circuit is connected to the anode. It was found that it also worked quite well as a push-pull driver, with the secondary emitter and the anode connected to the opposite ends of a push-pull resonant circuit as shown in Fig. 5. In the latter case, when used as a power amplifier, a power gain equivalent to 1.414 times that of the single-ended circuit was obtained.

External Circuits

A few words about the external circuits are in order at this point. At 500 megacycles the advantages of concentric resonant line circuits, either $\lambda/4$ or $\lambda/2$ in effective length, are numerous and these lines were used in the work of development. Proper matching of the input and output terminals of the tube to their connected circuits is most essential, as well as the effective grounding of the other elements at the operating frequency. If modulating signals are applied to one or both of the reflecting plates, then band-pass type filtering is required in the leads to these elements in order to properly ground the r-f carrier currents while passing the modulating signals.

In Fig. 5 it will be noted that provision is made for impressing a modulating signal onto the reflecting plates. Resistors R_0 and R_1 are in series with the battery leads to these plates. Generally only one plate is used for a single application; however, there are conceivable applications where both plates might be used for a dual modulation scheme.

In conclusion, it should be remembered that in order to control the electron flight time within a given tube, assuming constant velocity, a circular or orbital path with suitable deflecting plates must be provided, and to obtain the reactive or phase effects discussed herein the physical dimensions must be such to cause the flight time to be approximately equal to the time of one cycle of the operating frequency. Whether the tube is a secondary emitter or a straight anode collector does not matter in the sense and manner of control. It does, however, make a difference in the relative gain derived, being somewhat in favor of the secondary emitter type. A greater flexibility in circuit arrangements, with some added complications, is possible with the latter type.

Shielding of Dielectric

Dielectric heating generator (left) connected to shielded work table (right) by overhead transmission line

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THE rapidly increasing use of electronic heating processes in industry has required the installation of many high-power radio-frequency generators. All of these generators radiate some power and thus become potential sources of interference with radio services.

The investigation to be described was undertaken to determine by actual measurement the effect of various shielding arrangements upon the radiation from electronic heating equipment.

Electronic heating is divided into two distinct fields: the heating of metals, called induction heating, which is done mostly at frequencies below 500 kilocycles, and the heating of nonconductors, called dielectric heating, which is done almost entirely at frequencies above two megacycles.

Field strength measurements made around several 20-kilowatt, 400-kilocycle induction heating installations operating in manufacturing plants show that no measurable field strength exists beyond 300 feet from the equipment. Thus it appears that usually no shielding beyond that required for safety will be necessary for induction heating installations. Similar measurements made on two 15-kilowatt dielectric heating installations, operating near 10 megacycles without special shielding, gave average field strengths as shown in Fig. 1.

From a paper presented at the IRE 1945 Winter Technical Meeting in New York.

Radiation on harmonics of the operating frequency must also be considered. Figure 2 shows comparative field strengths of fundamental and harmonics measured at one commercial installation operating at 9 megacycles. A similar ratio of harmonic radiation was measured at the start of these tsts.

The ratio remained approximately the same as the fundamental field strength was reduced by shielding. The harmonics disappeared below the noise level while the fundamental was still easily measurable.

Usually the ambient noise level in localities where industrial equipment is used will be fairly high. Around the installations plotted in Fig. 1 it was about 20 microvolts. At the measuring position used in this investigation it was 15 microvolts.

Conditions of Tests

The tests were run on a dielectric heating generator located in the RCA development laboratory in Camden. The field strength measurements were made with an RCA 308A field intensity meter placed at a fairly open spot 360 feet from the generator. Later, when radiation had been considerably reduced, the meter was moved to 100 feet from the generator.

All readings were converted to the equivalent field at a distance of one mile by means of the inverse square law which, as Fig. 1 shows, fits the case quite closely. This was done to conform to the standard broadcasting practice and to provide a common base for comparison of all readings regardless of the distance at which they were taken.

In order to simulate the average factory installation, the applicator electrodes and work table were set up about 12 feet away from the generator and were connected with it by a concentric transmission line. The generator was housed in a partially copper-plated steel cabinet. Metal conduit extended from the cabinet to the incoming power source, the plate transformer, and the remote control station. In order to provide the usual safety ground, the system was also directly connected to a driven ground pipe by 5 feet of No. 4 solid copper wire.

The load on the generator consisted of a water resistance in series with a two-plate air capacitor formed by the applicator electrodes. The low-voltage electrode was the

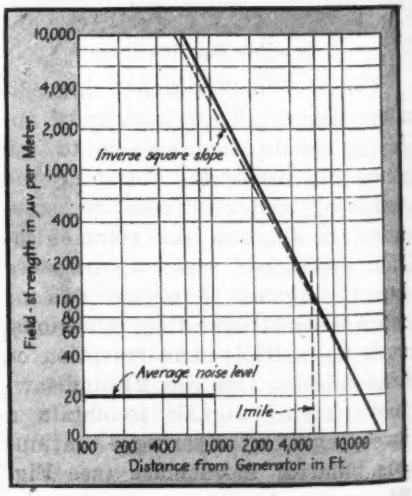


FIG. 1—Average field strength of two dielectric heating installations (solid line) closely follows the inverse square slope relation

Heating Installations

Field intensity measurements in the vicinity of a 9-Mc electronic generator show effects of various shields, grounding arrangements and line filters on radiation when feeding 6 kw into a dummy load. An oscillating wavemeter locates points of radiation leakage

sheet copper top of the work table. This arrangement is shown in Fig. 3. The plate power input to the generator was 6 kw, which remained constant throughout the tests. The frequency was 9 Mc. The voltage across the load was 4000 volts.

Unshielded Work Table

The first measurement was made with no shielding of any kind over the work table. The resulting field strength was 316 microvolts at one mile. From this starting point some

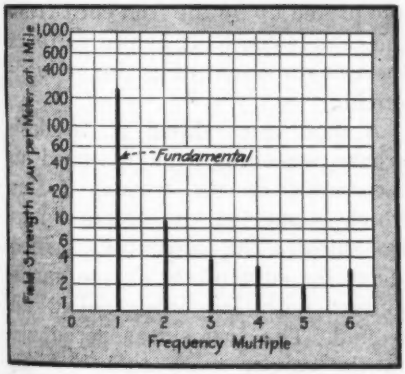


FIG. 2—Harmonic field strength from a 15-kw dielectric heating generator, measured at 900 feet and converted to one-mile values

150 readings were taken before the many sources of radiation were located and the field strength was reduced to noise level. However, only the more significant values will be mentioned here.

In order to determine how much of the radiation could be attributed to the incoming power line, a three-phase low-pass filter consisting of a pi arrangement of two 0.1-μf capacitors and a 4.4-μh choke per phase was mounted as in Fig. 4. At the time the field measurements were made on the industrial installations previously mentioned, this filter was inserted in the power

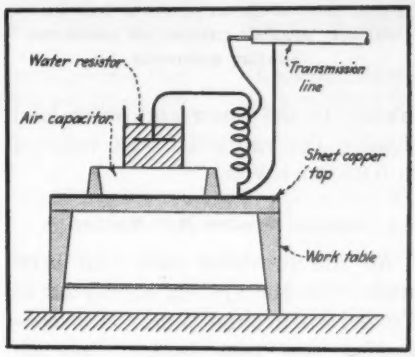


FIG. 3—Dummy load for work table, and method of shielding table with copper

line just ahead of the generator and check readings were taken at each place. No appreciable reduction in field strength could be found. The result was the same when the filter was tried in this test. Radiation from other sources was so strong that reduction of radiation from the power line was too small to be readable.

Use of Shielding Cage

The first attempt at shielding was to place a cage over the work table. This cage was 5 x 5 x 5 feet and was covered with 16-mesh bronze wire screening turned under the bottom edges so that it would make contact with the sheet copper work table top all around. The small access door was covered by a piece of $\frac{3}{32}$-inch sheet copper which overlapped the door opening about one inch on all four sides. This cage reduced the field strength to 1.3 microvolt.

To provide a very low-impedance return circuit a two-foot-wide sheet of copper was run from the work table top, under the door of the generator cabinet, direct to the oscillator filaments. The field strength

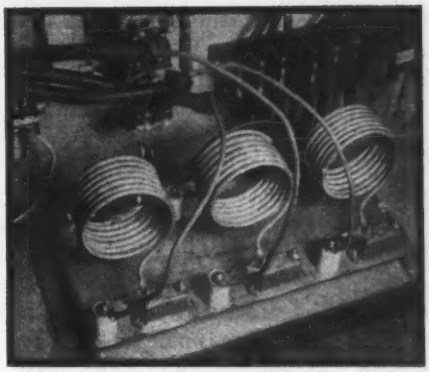


FIG. 4—Three-phase line filter inserted in the power line serving the electronic generator

was then reduced to 1.2 microvolt.

Following this a number of changes were made, such as insulating the low-voltage applicator electrode from the top of the work table, adding a three-inch tube shield over the $1\frac{5}{8}$-inch transmission line, and putting the applicator inside a second shielded box. All these changes produced variations in field strength, some increasing it, some decreasing it, but never getting it below about 0.93 microvolt. Even connecting and disconnecting the copper ground sheet from the cage made very little difference.

Then, for another reason, the ground sheet was removed from under the generator door and the field strength immediately dropped to 0.3 microvolt. The sheet acted as an antenna as long as it extended into the generator compartment. This indicated that about as much radiation was leaking out of the various holes and cracks in the generator cabinet as out of the work enclosure; consequently, the transmission line was disconnected from the generator and a means was sought of detecting points of maximum radiation around the cabinet.

Leakage Radiation Detector

The instrument finally developed for this detective work was a small shielded loop coupled to an oscillating wavemeter which provided indications on a grid meter for strong signals and by heterodyne beat in headphones for weaker signals. This instrument proved extremely valuable throughout the

investigation. It is shown in Fig. 5. With the help of the loop it was easy to find that the oscillator cabinet door joints were the strongest source of radiation. By coupling the loop close to the surface of the cabinet it was possible to map the direction of current flow around the various portions of the cabinet.

Causes of Leakage Radiation

Sealing the door was first attempted by bridging the joints with small copper clips, but this was far from satisfactory. Eventually the door was continuously bonded with weather stripping made of bronze screen extending all the way around. Only then did radiation from this source become undetectable.

Meters and controls which extended through the front panel were also quite capable radiators and had to be shielded by wire screening between the back of the panel and the r-f circuits. Radiation from the ½-inch mesh ventilator grill in the top of the cabinet was also strong until the ventilator was covered with 16-mesh screening. The remote control and safety interlock wiring were found to be good radiators and they were entirely disconnected. Thus one small source of radiation after another was eliminated until the field strength from the generator alone was reduced to 0.05 microvolt.

Addition of the transmission line and load then raised the radiation to 0.37 microvolt, whereas the value was 0.3 microvolt before any shielding was done on the generator cabinet. This result emphasizes the fact that the measurement of the field strength is not a particularly reliable method for determining the effectiveness of various shielding measures unless measurements are made at more than one point around the installation.

Two improvements in the generator shielding, each of which produced a definite reduction of field at the meter when applied separately, may often show an increase of field at the meter when applied together. Many interference effects of this nature were noted.

After some further improvements of the inner load-shield and after connecting the inner and outer transmission line tubes sep-

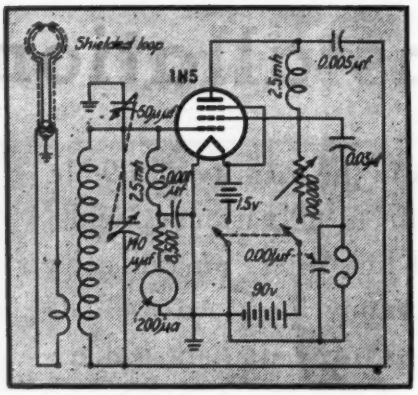


FIG. 5—Circuit of oscillating wavemeter used to detect points of radiation leakage around cabinet of electronic heating generator

arately to the inner and outer load shields, the radiation was reduced to 0.05 microvolt.

Special Ground Not Needed

All the previous tests had been made with the system connected to the driven ground pipe. This connection was now broken, but no change in field strength resulted. Connections to various other grounded objects were made and broken without effect. It appears that in a reasonably well shielded system, if any ground at all is required for reduction of radiation, the ordinary electrical conduit or Underwriters' safety ground is sufficient.

In order to make the installation complete, the remote control station wiring, which had been disconnected at the beginning of the tests, was replaced. The field went up to 0.74 microvolt and did not come down again until a warning lamp, which had been connected into the remote-control box with unshielded wire, was removed. This piece of rubber-covered cord had been the source of all radiation charged to the remote control wiring.

TABLE I. Summary of Shielding Tests

Conditions	Field Strength in μV/Meter Converted to 1 Mile	Total Attenuation in db
As Installed; No Load Shielding	316.	0
Single-Screen Cage Over Load	1.3	45
Generator Cabinet, Shielded	0.12	69
Double-Screen Cage Over Load	0.007	93
Double-Screen Door On Cage	0.0036	99
Slot 1x30 in. with 8 in. Extension	0.4	78

The above-described system of shielding was quite complicated. The double-shielded transmission line and double load-shield were particularly undesirable; therefore, an attempt was made to simplify the shielding without significantly increasing the field strength.

Soldering Iron Phenomenon

The outer transmission line tube was removed and both load-shields were connected to the remaining outer conductor. This doubled the indicated field strength to 0.09 microvolt. Removal of the inner load shield raised the value to 0.12 microvolt where it stayed, in spite of a number of additional changes, until a soldering iron was plugged into a nearby receptacle. The field strength immediately dropped to an extremely low value. This was another interference phenomenon which was found to be due to voltage picked up by the iron cord from the cage leakage. It helped to force the reinstatement of an inner load-shield.

A new inner shield of 16-mesh bronze screening was fastened to the inside of the wooden frame which supported the original single shield. The screening, turned under the edge of the frame, made contact with the outer shield all around. The frame was set down on the copper work table top as before. The field strength with this arrangement was 0.007 microvolt and no longer could any voltage be detected on the iron cord.

Effectiveness of Line Filter

Now that most of the other radiation had been eliminated, the line filter became an important part of the system, for when the filter was disconnected, the field strength rose to 0.31 microvolt. No further changes in arrangements inside the cage had any effect on the field strength. The insulated lower applicator electrode was removed, thus making the table top serve as the electrode and carry the total load current, but no appreciable increase in field occurred. The final arrangement is shown in Fig. 6.

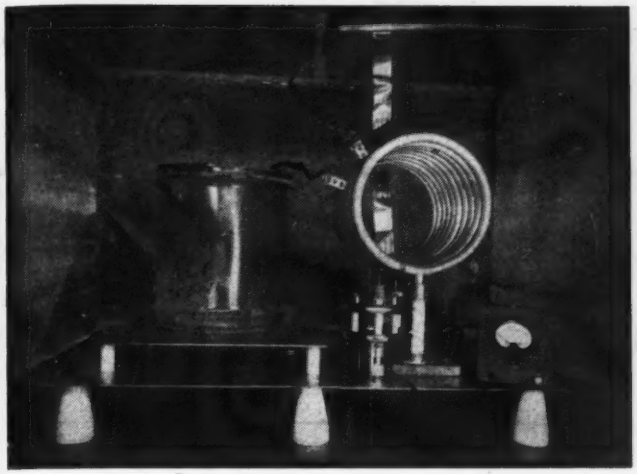
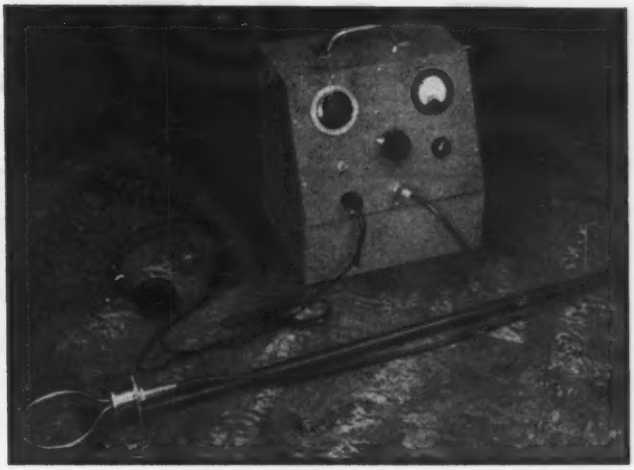


FIG. 6—Final arrangement of work table, with dummy load on low-voltage electrode that is insulated from the copper top of the work table



Radiation detector and search coil used for locating points around doors of shielded cage at which appreciable radiation was escaping into space

Up to this time a copper sheet bonded to the outer screen had been used as the cage door. This was now replaced with bronze screening bonded to the outer screen. The field rose from 0.007 to 0.01 microvolt. With the single screen door bonded to the inner screen the value went back to 0.007 microvolt, and with a double-screen door it dropped to 0.0036 microvolt. A field strength of 0.0036 microvolt is quite small compared to the original 316 microvolts; it represents a reduction of about 85,000 to 1.

Shield for Conveyor Applications

In some installations it is desired to pass the work continuously through the applicator by some means such as a conveyor belt. This requires an opening on each side of any shield which may be used. To investigate this condition a horizontal slot 30 inches long and adjustable in width was cut in the sheet copper cage door. With a slot $\frac{1}{8}$-inch wide, a field of 0.09 microvolt was produced. A one-inch slot raised it to 0.13 microvolt.

The first attempt at reducing this radiation was a sort of vestibule having the same cross-section as the slot and extending outward perpendicular to the side of the cage, as in Fig. 7. With a length of eight inches this device reduced the radiation from the $\frac{1}{8}$-inch slot to 0.01 and from the one-inch slot to 0.04 microvolt. These values compare favorably with those previously obtained. Although more work remains to be done it appears that the extension of the edges of a cage opening offers a possibility of providing open entrance and exit doors without allowing excessive radiation.

Summary of Results

For convenient comparison the most important values in this report, together with the corresponding attenuation in db, have been tabulated in Table I. In summarizing the results of this investigation it is well to divide the problem into shielding of the generator and shielding of the applicator. Since the shielding of the generator is the simpler of the two, it should be done as completely as possible. This involves three important points: first, the radio-frequency parts of the generator circuit must be enclosed in a separate section of the cabinet, the walls of which are copper plated and conductively bonded at the joints. (The copper provides a better and more permanent contact across wall joints).

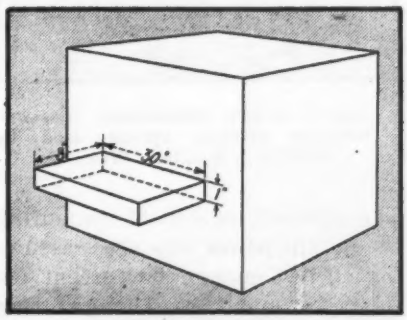


FIG. 7—Method of attaching a vestibule to the shielded cage of the work table, for providing conveyor belt openings without allowing excessive radiation

All wiring and components not essential to the r-f circuits should be kept outside of this r-f compartment. This refers to control wiring and especially meters or controls which may extend through the walls of the main cabinet. Any ventilators should be covered with small-mesh bronze screening. Second, any access door into the r-f enclosure must be conductively bonded along all edges. If this is not done, the door will be a major source of radiation. Third, a good low-pass filter should be provided in the power supply line.

The shielding of the transmission line and of the work applicator and tuning equipment will then control the amount of radiation from the system. When the double screen cage is used, the two screens may be in contact with each other at points such as access openings; both should maintain good contact with a single sheet-copper floor which may be used as an applicator electrode if desired.

No unshielded wires should be run into or out of the system. The use of special external ground connections, such as wires to water pipes or to buried plates, has no appreciable effect upon the reduction of radiation.

It is hoped that the findings of the foregoing investigation may serve as a reference for the economical construction of load shielding.

F-M Field Survey

Detailed description of the procedure used to secure data for plotting actual coverage contours of WMFM as required by the FCC one year after an f-m station first goes on the air, with practical data on equipping, calibrating and using a field car

ONE YEAR from the date of the first regular operation of a high-frequency f-m broadcast station, a survey must be submitted to the Federal Communications Commission establishing the actual field intensity contour. Continuous field intensity records are made along each radial specified in the construction permit (CP), and the actual routes of the field car are plotted on a map along with the two service contours. The primary service area then corresponds to the area inside the 1000-microvolt contour, and the secondary service area is inside the 50-microvolt contour.

Transmitter Power Requirements

During the months of August and September, 1943, a survey like this was made to prove the antenna performance of WMFM, one of the Milwaukee Journal's radio stations. In order that the calculated distance to the 50-microvolt contour would conform with the map attached to the CP, an effective radiated power of 41.5 kilowatts was necessary to deliver the desired coverage of 8500 square miles.

The radiating system of WMFM consists of a two-bay turnstile antenna which has a power gain of 1.23. The required transmitter power, for an effective power radiation of 41.5 kw, is therefore 41.5 divided by 1.23, or 33.8 kw. The loss in the coaxial transmission lines to the antenna was computed to be 2.5 kw, thereby requiring an increase in the transmitter output power to 36.3 kilowatts. WMFM uses a 50-kw REL 521DL f-m transmitter with a power input to the final stage of 60.5 kilowatts.

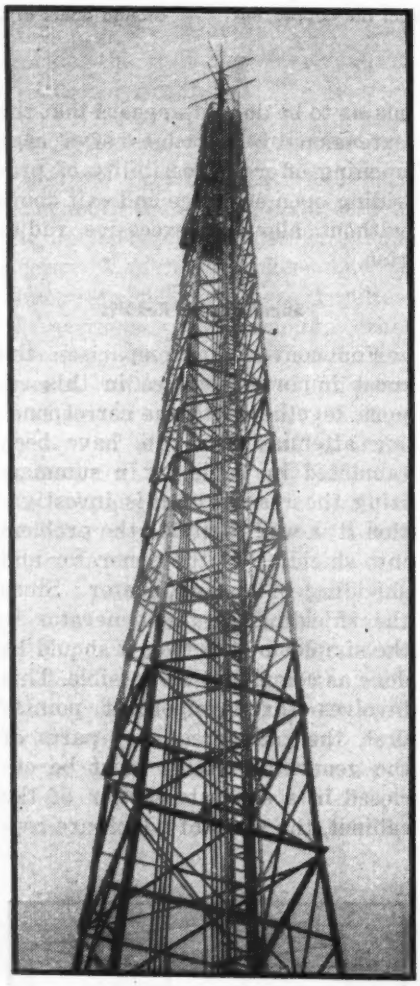


FIG. 1—Tower, transmission lines and turnstile antenna system used by WMFM at Richfield, Wisconsin

The indirect method of computing the output power was used, assuming an efficiency of 60 percent for the power amplifier. The operating power then is 0.6 $E_p I_p$, where E_p is the plate voltage applied and I_p is the total plate current of the last radio-frequency amplifier stage. This results in 36.3 kilowatts being fed to the transmission lines and an effective 41.5 kilowatts being radiated.

The turnstile antenna, shown in Fig. 1, is mounted on a 200-foot self-supporting tower and has a total effective height to the center of the array of 224 feet. The STL receiving antenna platform is incorporated in the tower design. The eight transmission lines on the tower, each feeding a single antenna element, can also be seen. The transmitter, located about 21 miles northwest of Milwaukee proper and about 15 miles inland from Lake Michigan, was described in a previous article.[1]

Measuring Equipment

The 50 and 1,000-microvolt contour lines were determined by taking continuous measurements along each of eight radials spaced 45 deg apart, using an RCA 301A v-h-f field intensity measuring set with a 93A vibrator power unit.

The field intensity meter was designed for measuring field intensities of stations operating in the high-frequency spectrum, for the purpose of checking antenna efficiency, service area and carrying out research or propagation studies. The instrument covers the band of 20 to 125 megacycles and has a range of 10 to 500,000 microvolts when used in the f-m band (officially designated as the high-frequency broadcast band). It is designed particularly for field use and consists of three units—the field meter, antenna and power supply. The primary source of power to the vibrator unit is a non-spillable storage battery de-

TECHNIQUES

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The Milwaukee Journal Radio Stations
Milwaukee, Wisconsin

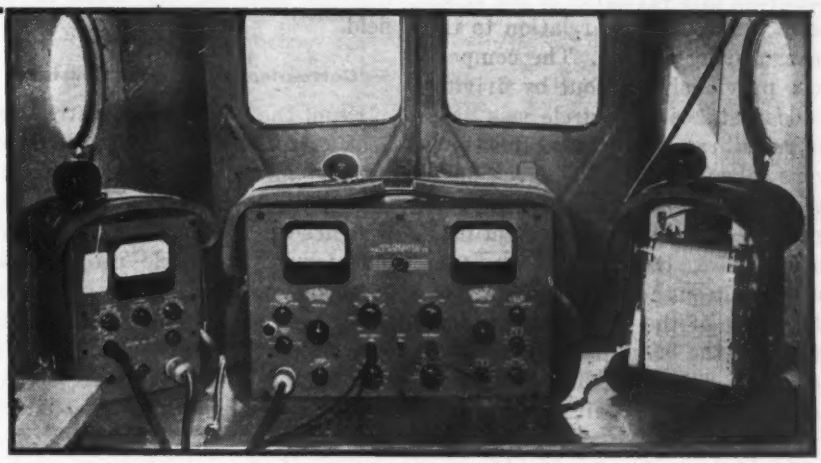

FIG. 2—View of the v-h-f field intensity measuring set mounted in the car and ready for use. At the left is a noise meter

signed to operate continuously for eight hours without recharging. The recorder was an Esterline-Angus model AW 5-ma instrument.

The equipment was securely mounted on rubber kneeling pads in a Dodge delivery truck, as shown in Fig. 2. In addition to these equipments an f-m receiver was taken along to monitor the station; this proved valuable at the outer fringe of the service area.

The antenna of the measuring set was mounted on the roof of the field car and the support extended down through to the floor inside. This made it possible to control the antenna from the inside while the field car was in motion. The antenna used at the transmitter is a horizontal turnstile, and consequently similar polarization was used for the car antenna. A marker was attached to the base of the antenna mast and set up to indicate the relative position of the dipole above. This was helpful when the field car made turns along the highway, and minimized time in orienting the antenna. The output of the antenna was connected by means of a flexible transmission line to the field measuring set, which in turn was connected to the Esterline-Angus recording milliammeter. Figure 3 is a picture of the field car with the antenna mounted in place.

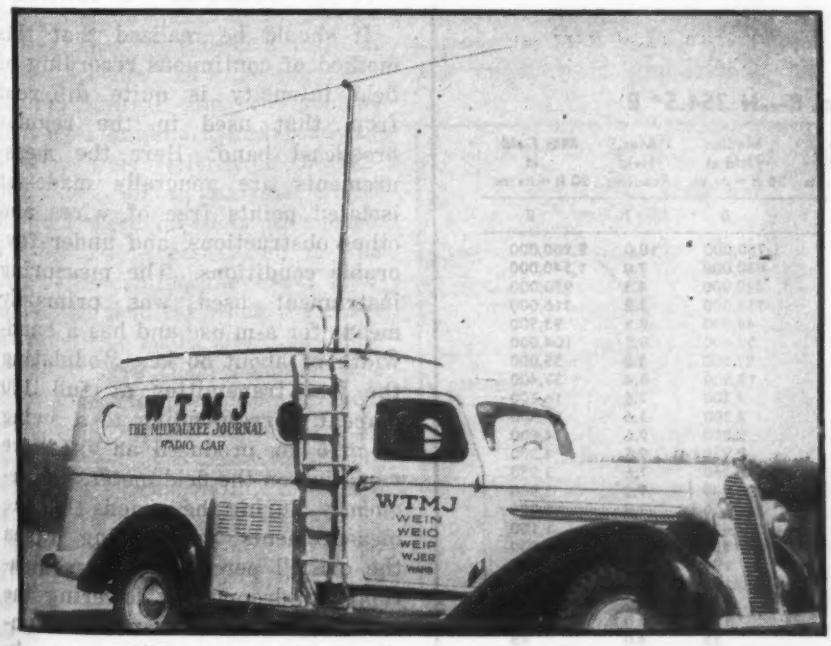

FIG. 3—View of the field car with the telescopic antenna raised. The antenna pivots on a bearing inside, permitting orientation for maximum signal

Calibration of Field Car Installation

The metal in the truck body made it necessary to check and recalibrate the measuring instrument. Therefore, before the equipment was installed in the field car the measuring set was taken to a location well away from and free of power lines, fences and buildings. The nearest obstacles were more than 300 feet distant. A compass rose was laid out and readings taken to determine the field intensity in this local area. The signal intensity in this open-field area was found to be 1634 microvolts, and no fading existed here to upset the calibration. The antenna length was 54 inches, or about 0.21 wavelength each side of the dipole for the above tests. The height of the antenna was adjusted to 13.5 feet, which was the maximum height of the telescopic support.

A semi-permanent installation was then made in the field car. It was found that the top of the truck body did not present a uniform capacitance back to the antenna as it was rotated over 360 degrees. After several tests it was determined that the antenna had

to be elevated slightly more than one quarter wavelength above the steel top in order to minimize the effect of the truck body. It was deemed necessary to set up and calibrate this variation as the truck body was rotated in relation to the transmitting station. The compass rose previously laid out by driving wooden stakes in a circle was used to recalibrate the unit. Readings were taken at each 30-degree position and the antenna always oriented to deliver the maximum field intensity as the truck body was rotated through 360 degrees. The placement of the antenna with reference to the body of the truck can be seen in Fig. 4, which corresponds to the 270-degree position shown in Table I.

The highest signal intensity was received at positions 2 and 8, corresponding to 1577 μv per meter. The lowest signal received was 1520 μv per meter, at positions 4-5-6-7. Prior to the installation on the field car, a signal of 1634 μv per meter was received at this identical location. This represents a reduction of 57 microvolts at positions 2 and 8 and 114 microvolts at 4-5-6-7 when introducing the metallic body of the truck in the field.

Correction of Antenna Constant

From the data in the instruction book furnished with the field intensity instrument it was found that an antenna constant of 9.5 was needed to carry out the computation for the field intensity at 45.5 megacycles. This constant takes care of any losses in the 30-foot transmission line from the dipole to the input terminals of the field meter. Changing this constant was a very convenient way to compensate for any effect that the truck body might have on the pick-up antenna. The new constant K was found by the following formula: $K = 1634\ \mu v \div$ attenuator scale $\times$ meter reading in milliamperes.

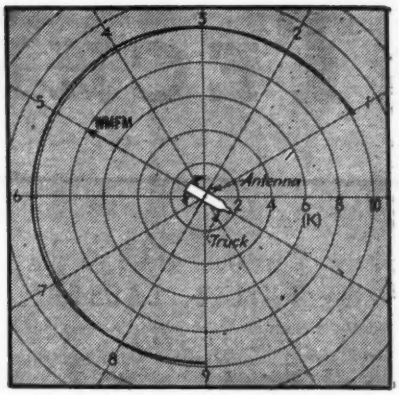

FIG. 4—Graph showing the variation of the antenna constant with the position of the field car in relation to the direction of the transmitter as the only variable. The dipole antenna was oriented for maximum signal for each new position, and the transmitter power held constant

The field unit was used only for measurements while moving directly away from the transmitting station, and therefore calibrations were made for only the rear and the two sides of the truck, as shown in Fig. 4. Positions 2 to 8 were averaged, and resulted in a change of the antenna constant from 9.5 to 10.0. The overall height of the antenna then was permanently fixed on the field car at 13.5 feet above the ground or 6.5 feet above the metal roof. After all the radials were run, the calibration of the measuring set was again checked under the same conditions and found to be the same.

Percent Modulation Was Lowered

It should be realized that this method of continuous recording of field intensity is quite different from that used in the regular broadcast band. Here the measurements are generally made at isolated points free of wires and other obstructions, and under favorable conditions. The measuring instrument used was primarily meant for a-m use and has a bandwidth of about 50 kc. Modulating the f-m transmitter at full 100 percent, corresponding to a swing of ± 75 kc, produced an excessive variation on the field meter. Consequently, during the periods that the measurements were being taken the overall percentage of modulation was dropped by lowering the audio input to the transmitter until satisfactory stability was obtained. This was achieved by low-

TABLE I. EFFECT OF TRUCK BODY ON ANTENNA CONSTANT

Position No.	Position Angle	Attenuator Scale	Reading in ma	Field Intensity in μv/m, using K=9.5	New Antenna Constant K
1	60°	20	8.1	1539	10.08
2	30°	20	8.3	1577	9.85
3	360°	20	8.2	1558	9.96
4	330°	20	8.0	1520	10.21
5	300°	20	8.0	1520	10.21
6	270°	20	8.0	1520	10.21
7	240°	20	8.0	1520	10.21
8	210°	20	8.3	1577	9.85
9	180°	20	8.3	1577	9.85

TABLE II. RADIAL No. 8—N 354.5° E

Sector Number	Attenuator Setting	Dist. to end of Sector	Median Field Reading	Median Field at 13.5 ft = μv/m	Median Field at 30 ft = μv/m	Max. Field Reading	Max Field at 30 ft = μv/m
1	2	3	4	5	6	7	8
1	10,000	0.6	8.0	800,000	1,760,000	10.0	2,200,000
2	10,000	1.0	4.0	400,000	880,000	7.0	1,540,000
3	10,000	2.4	2.0	200,000	440,000	4.3	950,000
4	2,000	3.5	3.0	60,000	132,000	7.2	316,000
5	500	5.0	4.0	20,000	44,000	8.5	93,500
6	500	7.0	5.2	26,000	57,400	9.5	104,000
7	500	9.0	2.5	12,500	27,500	5.0	55,000
8	500	10.6	1.8	9,000	19,600	3.4	37,400
9	100	12.5	3.5	3,500	7,700	7.6	16,700
10	100	16.0	1.5	1,500	3,300	5.6	12,300
11	20	20.0	6.4	1,280	2,820	9.6	4,200
12	20	25.0	5.1	1,020	2,250	9.8	4,300
13	20	27.5	4.0	800	1,760	7.6	3,350
14	20	32.5	2.6	520	1,140	9.0	3,960
15	20	36.0	1.5	300	660	3.9	1,720
16	5	40.0	4.0	200	440	10.0	1,100
17	5	42.5	5.0	250	550	10.0	1,100
18	5	45.5	1.8	90	196	6.6	722
19	1	50.0	5.5	55	121	10.0	220
20	1	55.0	6.2	62	136	9.6	212
21	1	60.0	6.0	60	132	10.0	220
22	1	65.0	1.5	15	33	4.0	88
23	1	70.0	2.0	20	44	6.1	134

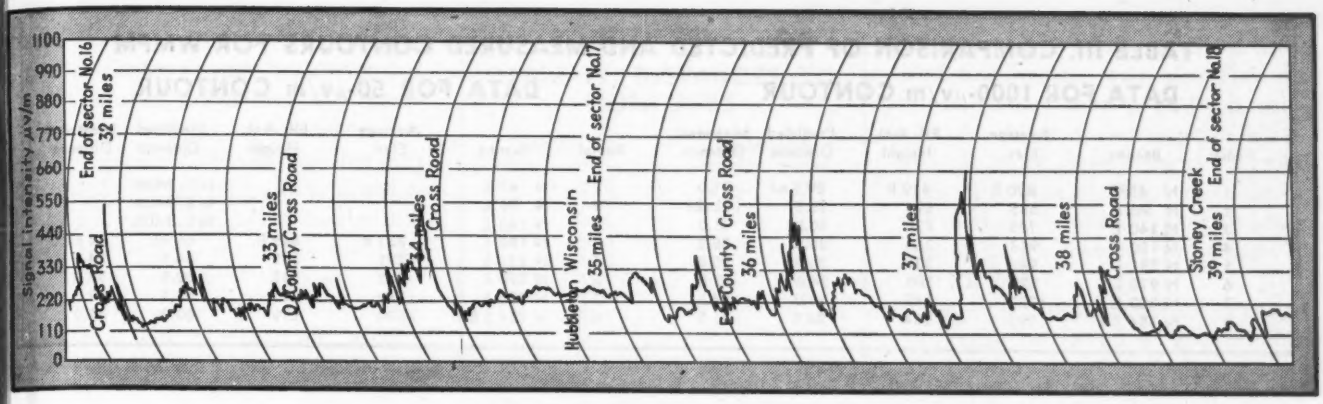

FIG. 5—Signals recorded with equipment shown in Fig. 2 and 3

ering the input 4 to 5 db. Satisfactory monitoring of the program modulation could not be obtained with this amplitude instrument so the signal was monitored on the f-m receiver which was carried along.

Field Work and Routes

In planning for the runs on each of the eight radials, care was taken to see that they were carried well beyond points of predicted service, so as to arrive at a sufficiently accurate determination of the contour boundary. This is particularly important at the 50-microvolt contour because of distance to be retravelled if the field records are found to be incomplete. The radials were spaced approximately 45 degrees about the transmitter.

The survey was conducted only during the daylight hours. While driving along the radials a uniform driving speed of 15 miles per hour was maintained and a sufficient number of landmark and roadway notations were written on the record for later chart analysis. These locations were noted on the chart as often as necessary, so it was easy to determine the exact location of the field car when the chart analysis was made later on. This definitely fixed the relation of the car location to the measured field intensity. Figure 5 shows a record taken on radial 6 between sectors 16 and 18, corresponding to 32 and 39 miles from the transmitter.

In choosing the routes for the car, roads were chosen that ran parallel (or nearly so) to the radials, as deviations of the topography can cause a great difference in the recorded results. The routes traveled by the field car in relation to each radial are shown in Fig. 6. In some cases wide deviations from the radials were necessary because of rivers and their lack of bridges. This was the case on radial No. 1 where it was impossible to cross the Milwaukee River. Another case was on radial No. 5 at Janesville, where the Rock River interfered. On the northwest radial a large area known as Horicon Marsh made passage impossible. Most township roads run east and west, with very few diagonal roads, hence trouble was also experienced with the radials going northwest, southwest and northeast. On the southeast radial a diagonal highway, U.S. 41, ran directly along the radial and through the city of Milwaukee.

The antenna height above the car proved to be rather awkward during the field runs and trouble was experienced, particularly on country roads. The antenna had to be replaced several times because of the driver's inability to spot electric fence wires strung rather low across the highway, or because of overhanging branches. One radial per day was all that could be accomplished. This was partially due to the regular program schedule which began at noon and therefore necessitated a late start.

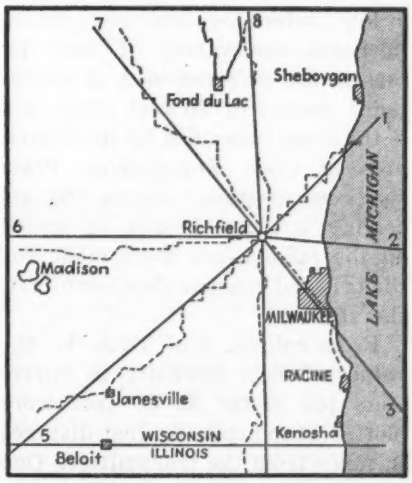

FIG. 6—Map of the eight radials, showing the deviation of the routes traveled by the field car (dashed lines) with respect to the radials

Predicted vs. Measured Results

After the measurements were completed, the charts from the recording meter were analyzed. The first step was to divide them into sections, each representing a sector of a radial along the topographic map. Each sector was not more than one tenth of the service radius or not more than five miles in maximum length. The charts of the field intensities were analyzed to determine the electric field intensity obtained 50 percent of the distance along each sector.* This will be referred to as the median field intensity for antenna height of 13.5 feet. The value is associated with each particular sector and is presented in tabular form. An example of one of these tabulations, shown in Table II, was compiled from the data taken along radial 8.

Column 1 of Table II is the sec-

* In the Standards of Good Engineering Practice for High Frequency Broadcast Stations[2], set up by the Federal Communications Commission, is the definition: "The signal intensity for the 50-microvolt per meter 50 percent distance is interpreted to mean the contour bounded by the sector on a radial on FCC map No. 41722, Signal range for high frequency broadcast stations, wherein the signal of the station for 50 percent of the distance represented by the sector of the radial is equal to 50 microvolts per meter. The boundary of the service area shall be taken as the outer edge of the sector nearest the transmitter wherein the signal is the desired value for 50 percent of the distance."

TABLE III. COMPARISON OF PREDICTED AND MEASURED CONTOURS FOR WMFM

DATA FOR 1000-μv/m CONTOUR						DATA FOR 50-μv/m CONTOUR					
Radial	Bearing	Average Elev.	Eff. Ant. Height	Predicted Distance	Measured Distance	Radial	Bearing	Average Elev.	Eff. Ant. Height	Predicted Distance	Measured Distance
1	N 45°E	800 ft	479 ft	29.1 mi	31.0	1	N 45°E			In L. Mich.	
2	N 96 E	685	594	31.5	In Lake	2	N 96 E			In L. Mich.	
3	N 140 E	745	534	30.8	31.0	3	N 140 E			In L. Mich.	
4	N 180 E	913	366	26.5	28.2	4	N 180 E	837 ft	442 ft	66 mi.	64 mi
5	N 231 E	946	333	25.5	25.6	5	N 231 E	891	388	64.5	64.5
6	N 270 E	979	300	24.8	23.0	6	N 270 E	932	347	62.5	58.0
7	N 320 E	1030	249	23.0	24.5	7	N 320 E	982	297	60.5	59.0
8	N 354.5 E	995	284	24.1	31.5	8	N 354.5 E	1000	279	60.0	65.0

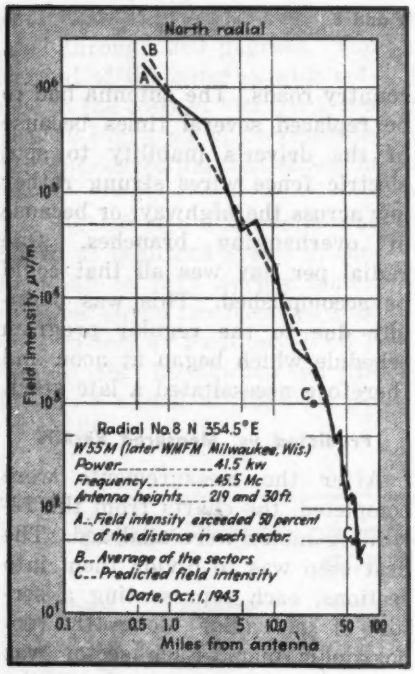
North radial
Field intensity, μV/m
Radial No.8 N 354.5°E
WSSM (later WMFM Milwaukee, Wis.)
Power.....41.5 kw
Frequency.....45.5 Mc
Antenna heights.....219 and 30 ft.
A...Field intensity exceeded 50 percent of the distance in each sector.
B...Average of the sectors
C...Predicted field intensity
Date, Oct. 1, 1943
Miles from antenna

FIG. 7—Graph constructed from data given in Table II. Similar graphs were made for each of the other seven radials

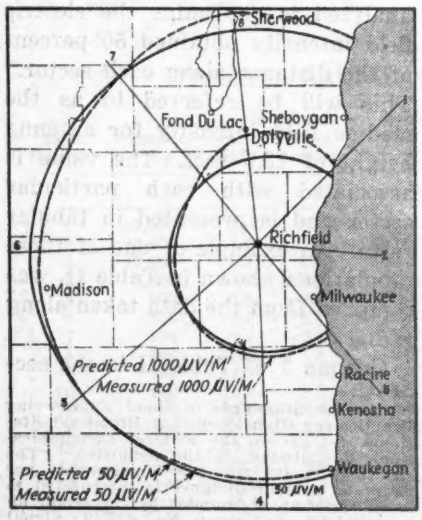

FIG. 8—Map showing the measured 50 and 1000-microvolt contours as heavy dashed lines. The solid line represents the predicted contours. The primary service extends to the far side of the city of Milwaukee and its southern suburbs

tor number. The next column is the attenuator setting on the field meter. Column 3 shows the distance from the transmitter to the end of each sector. Column 4 is the median field reading in milliamperes 50 percent of the distance along each sector. The fifth column is the field intensity already computed directly in microvolts at 13.5 feet. This is the product of column 2 and column 4 multiplied by the fixed antenna constant of 10.0. Column 6 is the median field intensity at 30.0 feet. Since the field intensity is directly proportional to the antenna height (above ½ wavelength) for horizontal polarization, a factor of 2.2 was used to interpolate the field intensity values from 13.5 to 30 feet. Column 7 shows the maximum field reading in milliamperes in each sector for an antenna height of 13.5 feet. The last column is the maximum field intensity obtained about 10 percent of the distance at 30 feet, and represents the peak signal value in each sector.

For reference and comparison purposes the values of field intensity are referred back to an antenna height of 30 feet since this is the height specified by the Standards of Good Engineering Practice. In addition, this is the receiving antenna height at which all the calculations were made for the original construction permits of the station.[3, 4, 5, 6]

From column 6 of Table II, the values of field intensity in microvolts per meter at 30 feet were plotted graphically against distance in miles from the transmitter. One of the eight graphs is shown as Fig. 7. The solid line is the measured signal intensity 50 percent of the distance in each sector. The dashed line represents an average struck to obtain the signal intensity at any intermediate distance. Indicated also are the two predicted contour points, shown by the letter notation *C*. It is evident that on this radial both contours fell inside the calculated distance.

A comparison of measured and predicted values of field intensity at WMFM for all eight radials is shown in Table III. Each contour distance was tabulated along with the predicted distances as stated in the construction permit issued by the FCC. Notice that the 50 μv per meter contour to the northeast, east and southeast falls in Lake Michigan and could not be measured.

Figure 8 shows the map constructed from the data given in the previous chart. The solid lines on the map represent the predicted 50 and 1,000-microvolt contours, while the dashed lines show the actual measured contours.

The 5 and 2.5-millivolt contour lines are not drawn on the map, but Table IV shows the distances at which these lines fall.

The total area covered by the transmitter is about 12,000 square miles. Thirty percent of this area falls in Lake Michigan, as may be seen by referring to the map. The Milwaukee trade area extends many more miles to the north and west than it does to the south.

Analysis of Discrepancies

The predicted area, not including the lake, was 8,500 square miles, which is the area specified in the present license for WMFM. The actual measured area inside the 50-microvolt per meter contour was 8400 square miles or a decrease of about one percent. The

area inside the 1,000 microvolt per meter contour was predicted at 1,860 square miles and the measured area was found to exceed this by 90 square miles or an increase of about five percent. This discrepancy between calculated and actual values is attributed to the inability to obtain accurate values of elevation of the topography to the north on radial No. 8 when the prediction was made for the construction permit. It is along this radial where the predicted signal was exceeded. This section of the state of Wisconsin had never been surveyed, and therefore there were no quadrangle maps. The records available gave only such sparse data as the positions of railroad stations, airport elevations and the like. The data on the area was computed by the use of a planimeter on the original airway map.

Within the 1,000-microvolt contour, the population was estimated at 834,607 based on the 1930 census figures. The predicted and measured distances to the service contours on the various radials are essentially the same with the exception of radial 8. The contour distance at this point extends about 7 miles farther out but no city of any size is included in this additional area. This small variation from the predicted contour makes no appreciable change in the population served by the station.

Within the 50-microvolt contour, the population is estimated at 1,522,544. In general, the measured results show the 50-microvolt line to be 2 to 3 miles inside the predicted distance. Exception again is made in the case of the north radial

TABLE IV. DISTANCES TO CONTOURS

5 Millivolt		2.5 Millivolt	
Radial	Miles	Radial	Miles
1	17.0	1	27.0
2	14.0	2	....
3	17.5	3	22.8
4	15.0	4	20.0
5	12.5	5	17.6
6	12.0	6	16.0
7	13.0	7	17.0
8	16.6	8	22.0

8, where the measured distance exceeded the predicted by 6 miles. This variation makes no appreciable change in the population figures within the 50-microvolt service area.

At the 50-microvolt point noticeable fading existed on several radials. This tended to influence the analysis of the field measurements and resulted in a lower than predicted value of field intensity in some areas. Milwaukee proper and its suburbs has a population of 766,885 and makes up the major market area of the station.

Fading

In conclusion, a few words on the stability of the signal intensity at the outer fringe of the service area and points closer may be of interest since experience has shown that appreciable fading can exist. After reaching the end of a particular radial a few minutes were spent checking the approximate placement of the 50-microvolt contour. This was done so that on the return trip along the same route a suitable spot could be picked as close to the contour as possible for a spot check on signal fading. A position was chosen for these checks which was representative of the country traveled and which was also free of wires, rather than a position suitable for high or low signal intensity. In most cases several hours of recording was done at the close of the daylight hours and shortly after sunset, to observe diurnal effects if any existed.

One recording location was at Dotyville, on radial 8, just outside the 1,000-microvolt or primary contour line. It gave a signal of 225 microvolts maximum and 160 minimum at 13.5 feet. This is an overall variation of 65 microvolts with a median signal of 200 microvolts. The distance to this point from the transmitting antenna was 34 miles.

Another location at which fading was observed is at Sherwood, also on radial 8, but near the 50-microvolt or secondary service contour. The distance here was 65 miles to the transmitter. The signal reached a maximum of 25 microvolts and a minimum of 7 with a median signal of 17 microvolts over a period of 22 minutes, as shown in Fig. 9. These checks were made with an effective antenna height of 13.5 feet, and to be correct should be multiplied by a factor of 2.2.

References

(1) Laeser, P. B., Planning an F-M Station, ELECTRONICS, p. 92, February 1945.

(2) Federal Communications Commission, "Standards of Good Engineering Practice for High Frequency Broadcast Stations", Annex II.

(3) Federal Communications Commission, "Field Intensity Survey of Ultra High Frequency Broadcasting Stations", Bulletin 40004.

(4) Singer, Charles, Field Strength Survey Methods, *F-M Radio and Television*, Feb. and March 1942.

(5) Guy, Raymond F., Frequency Modulation Field Tests, *RCA Review*, October 1940.

(6) Norton, K. A., Ground Wave Field Intensity Over Finitely Conducting Spherical Earth, *I.R.E.*, 29, No. 12, p. 623, Dec. 1941.

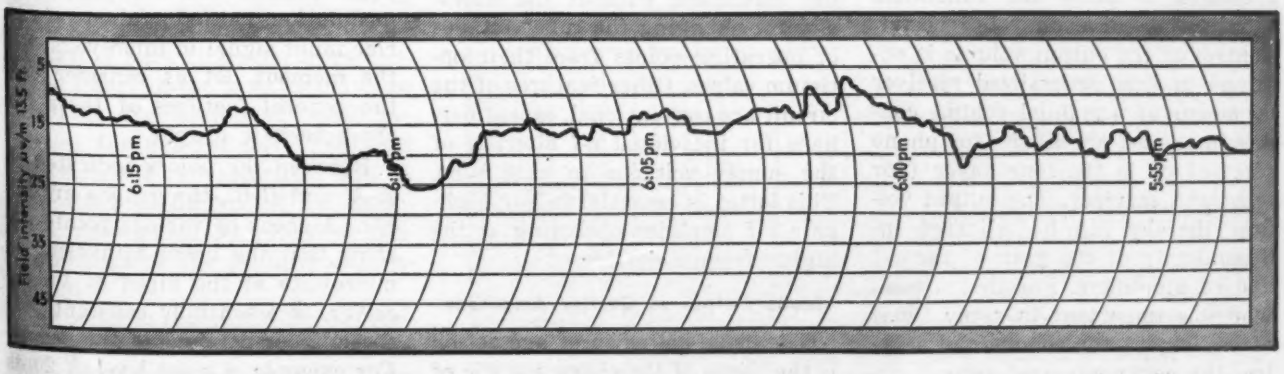

FIG. 9—Record of the fading at Sherwood, Wisconsin, on radial No. 8 at a point 65 miles from the transmitter and just barely inside the service area of WMFM

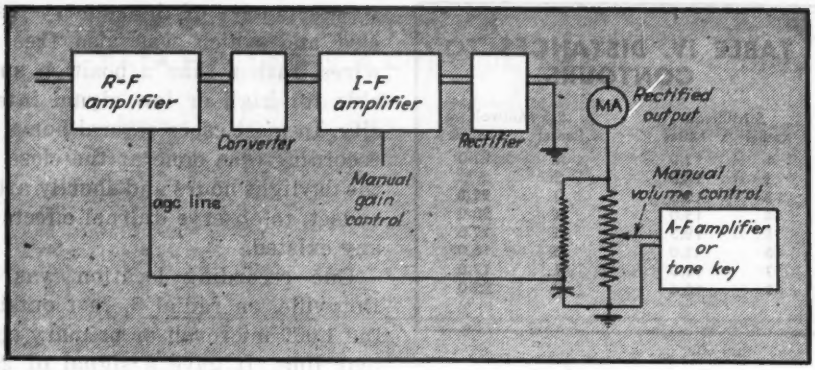

FIG. 1—Stages in a typical communications receiver having automatic gain control of the r-f amplifier

AGC-Noise Considerations in Receiver Design

Automatic gain control is considered for communications receiver service from the standpoint of its effect on signal-to-noise ratio at various signal voltages. The desirability of employing high gain in controlled stages and the limitations of such use are pointed out

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AUTOMATIC control of the output volume of radio receivers is so universally employed that there is apt to be a tendency to simply incorporate it in any design as a matter of course. It is the purpose of this present treatment to point out and discuss some of the factors that are not always obvious but that are important where the best possible performance must be obtained, as in commercial communications service; also, to deal with certain compromises that often must be made.

The simplified diagram given in Fig. 1 is a generalized schematic arranged to show the functional sub-divisions of a complete receiver. Control of the output volume is obtained in this generalized receiver by means of a manual volume control in the a-f amplifier (for phone service) or in the tone keyer (for telegraph service). The output volume thereby can be adjusted independently of the gain of the r-f and i-f amplifiers. For this reason, which is important in many types of equipment for commercial service, the commonly-used term *automatic volume control* (avc) is not applicable. The preferable term, which will be employed in this discussion, is *automatic gain control* (agc).

Figure 2 gives a generalized schematic circuit of a three-stage r-f amplifier, with agc, such as might be used in the complete receiver of Fig. 1. A particular feature to be noted in this circuit is the use of taps on the tuned-circuit inductances. The purpose of these is to make it possible to obtain any desired value of overall gain, up to the maximum, without the necessity for changing the tube voltages or operating points from their optimum values. Other features of the circuit are conventional, except perhaps for individual r-f filtering of the supply voltages to each tube. This latter is essential in any high-gain r-f amplifier operating at the higher frequencies.

Diode Output vs Carrier Amplitude

The usual criterion of agc action is the shape of the characteristic of rectified output vs r-f carrier input. Such a graph shows how nearly constant the output is maintained over the indicated range of r-f input voltage. For some purposes, this is sufficient. Such data do not, however, show what the signal-to-noise ratio in the output will be. For reasons which will be brought out in following paragraphs, this signal-to-noise performance may be quite different over a wide range of r-f input voltages than one would be led to expect from a statement of noise equivalent of the receiver.

In Fig. 3 are shown two typical graphs of output noise level, expressed in db below 100 percent modulation, plotted against r-f carrier input signal in microvolts. For the moment, let us consider only the general features of these two characteristic graphs.

Between the points indicated by *A-A'* and *B-B'*, the graphs are linear. A check of various points will show that the noise equivalent, in microvolts at the input of the receiver, is essentially constant over these linear portions of the graphs. For example, a noise level of 20 db below 100-percent modulation at

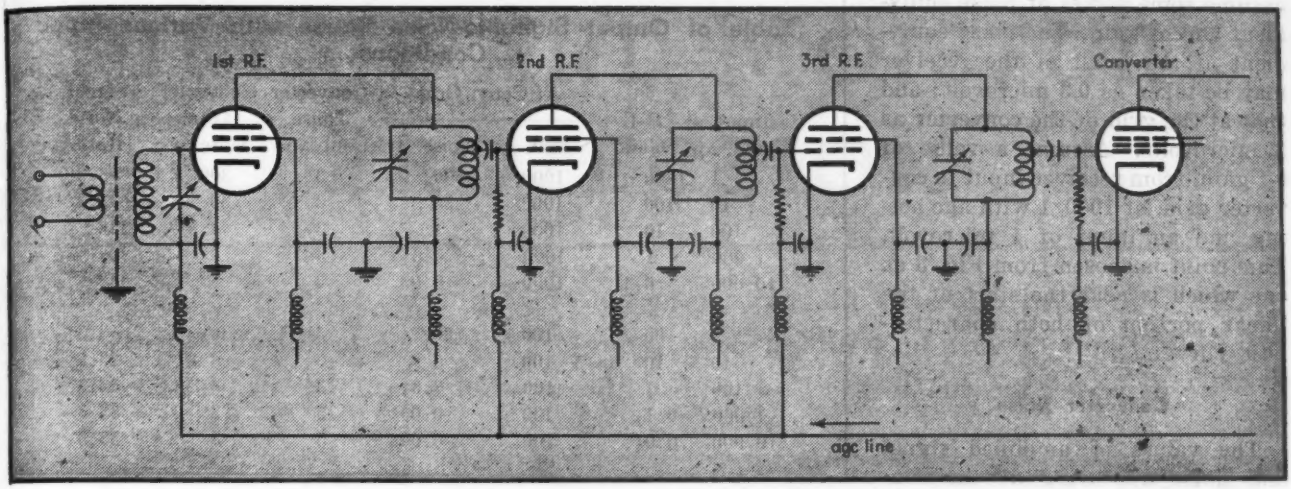


FIG. 2—Three-stage r-f amplifier and converter used for purposes of discussion by the author. Taps on the inductances permit adjustment for any desired value of gain without changing other operating conditions

a carrier input value of 2.6 microvolts (average) gives a noise equivalent of 0.26 microvolts at the receiver input. This method of expressing noise levels is convenient and useful because it provides a figure which can be compared directly with values of r-f signal input in microvolts.

Effect of Increased Signal

The ideal condition is that one in which the noise equivalent, at the receiver input, is constant regardless of signal strength. Then, and then only, is the full benefit of increased signal strength realized. In the curves of Fig. 3, it will be observed that the characteristic does not continue linear at the higher values of input signal. Instead, each characteristic levels off. Increasing the signal input ten times, from 100 microvolts to 1,000 microvolts, does not produce a corresponding improvement in signal-to-noise output of the receiver. A further increase from 1,000 microvolts to 10,000 microvolts produces an even smaller improvement. As a practical matter, there is no object in having such characteristics continue linear down to extremely low levels in the design of radio receivers for general use. The level at which the characteristic will be permitted to flatten off is, therefore, determined by practical considerations of the performance required.

In order to compare different performance curves directly, some common base or starting point must be used when making the measurements. For the curves of Fig. 3, the starting point was a diode output of 0.1 ma for zero r-f input signal. The particular equipment used in the tests maintains a diode output of approximately 0.6 ma at normal operating values of signal strength. In other equipment, a similar ratio between normal output and starting-point output of the diode could be used. Adjustment to the desired value of rectified output for zero r-f signal input is obtained by means of the manual gain control associated with the i-f system as shown in Fig. 1.

The flattening-off level, for such curves as those of Fig. 3, is determined by the amount of r-f gain employed between a given input stage and a given converter (Fig. 1). Three stages are shown to give the required r-f selectivity and also the desired agc action as judged by constancy of output over a wide range of r-f signal input. The overall gain is fixed at a desirable value by proper choice of the positions of the taps on the coils of the tuned circuits. This permits obtaining the desired reduction of maximum gain without changing tube voltages and operating points and thereby sacrificing agc performance.

To explain the foregoing, let us

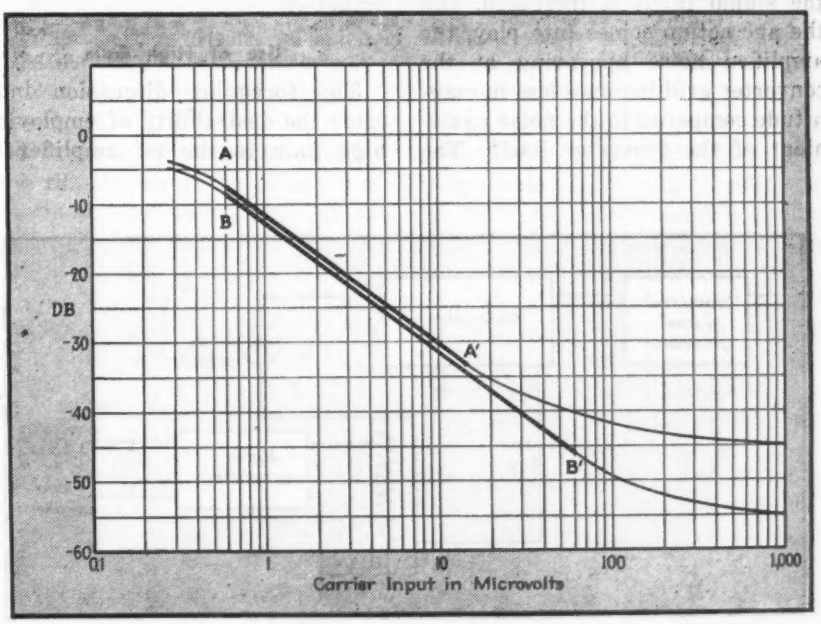


FIG. 3—Output noise level in db below 100-percent modulation, plotted against r-f carrier input signal in microvolts

assume some values of noise equivalent and of gain. The noise equivalent at the input of the receiver may be taken as 0.3 microvolt; and that at the grid of the converter as 3 microvolts. Assume a value of r-f gain, from receiver input to converter grid, of 1000/1 with agc acting and an input of 1 microvolt. This point is chosen from Fig. 3 as one which is near the start of the linear portion of both characteristic curves.

Table of Output Signal-to-Noise Ratios with Various Input Conditions

Input Signal, μv	R-F Gain	At Conv. Grid. Signal, μv	At Conv. Grid. Noise, μv	Converter Noise Equiv., μv	Converter Total Noise, μv	Signal Noise Ratio
1	1000	1000	300	3	300	3.3
10	100	1000	30	3	30	33.3
100	10	1000	3	3	4.2	238
1,000	1	1000	0.3	3	3	333
10,000	0.1	1000	0.03	3	3	333
1	100	100	30	3	30	3.3
10	10	100	3	3	4.2	23.8
100	1	100	0.3	3	3	33.3
1,000	0.1	100	0.03	3	3	33.3
10,000	0.01	100	0.003	5	3	33.3

Converter Noise

The values of amplified signal and noise appearing at the converter grid for different values of r-f input are given in the accompanying table. These are based on the somewhat idealized assumption that the agc action holds an absolutely constant output and therefore a constant signal level at the grid of the r-f converter. The assumption also is made, for the purpose of this simplified illustration, that the second and third stages contribute no appreciable portion of the noise. For purposes of illustration, these assumptions are justifiable; the errors involved being too small to appreciably affect the validity of the illustration.

The tabulated figures show that at low levels of input signal the final signal-to-noise ratio in the output of the receiver is determined by the signal-to-noise ratio existing at the input of the receiver. As the signal input is increased, and the agc action comes into play, the amplified noise appearing at the converter grid becomes less in magnitude compared to the noise equivalent of the converter itself. The result is that, at the higher levels of signal, the signal-to-noise ratio of the output of the receiver is determined not by that existing at the input but rather by the noise equivalent of the converter. The agc-characteristic of signal-to-noise vs r-f input therefore flattens off as shown in Fig. 3.

In the lower portion of the table, the r-f gain is assumed to be 100 instead of 1000. This lower value of r-f gain results in poorer signal-to-noise ratios at the higher values of signal input. The curve for this case therefore would flatten off at a considerably higher level of noise. This is illustrated by the two curves of Fig. 3, which are plotted from actual data rather than from the assumed data tabulated in the table for purposes of simplified explanation.

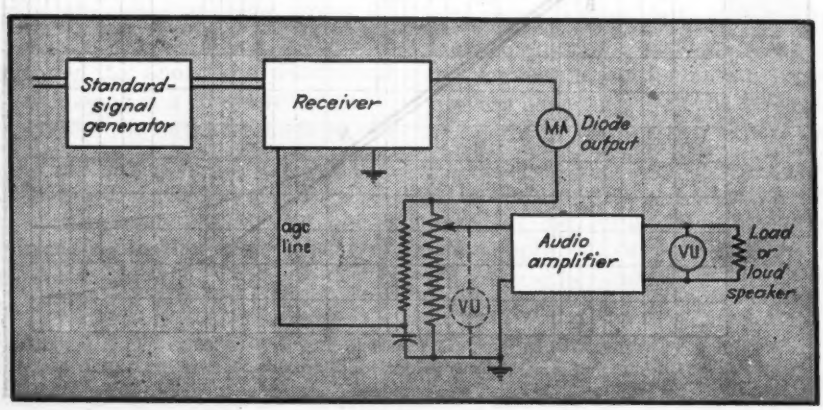
Use of High Gain

The foregoing discussion indicates the desirability of employing high gain in the r-f amplifier to which agc is applied. There are certain limitations, though, to the amount of gain that can be safely used. One is stability, or freedom from self-oscillation, at all frequencies. A second is protection of the r-f converter tube from being overloaded by stronger signals on channels adjacent to the desired signal.

If the r-f gain and the agc hold the desired signal at 10,000 microvolts at the grid of the converter, and a signal 100 times as strong as the desired one is received on an adjacent channel, the interfering signal will have a voltage of about one volt at the grid of the converter. This is apt to produce serious overloading and interference.

In actual use of a receiver such as depicted in Fig. 1 and having agc-noise characteristics as shown in Fig. 3, it is customary to manually readjust the i-f gain in order to obtain optimum performance on very weak and also on very strong signals. In this way the agc-noise characteristic may be shifted from its positions shown on Fig. 3 to best handle existing conditions and ranges of signal strength, noise, and interference. Obviously, the design of the agc system should be such as to cover the greatest possible range of input signal without the need for manual re-adjustment of the i-f gain.

The final design generally must be a compromise between the various factors discussed; the exact compromise being determined by the performance required and the conditions under which the equipment will be used.



Arrangement of equipment used to determine the output current of a diode at various carrier signal levels

FUNGUS AND MOISTURE PROTECTION

Treatment of equipment to permit operation under climatic extremes involves—among other factors—consideration of surface conditions, qualities of finish, and fungistatic values established. These are discussed here in the light of current information

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As applied to the protection of electronic equipment against unfavorable ambient conditions, the term tropicalization refers to (1) keeping out moisture to prevent electrical leakage, (2) inhibiting fungus attack and consequent loss of insulation resistance, and (3) forestalling corrosion which results from both moisture and fungus.

Tropicalization is more than a wartime requirement. It is forced upon us in any location where continuous high humidity combined with rapid changes of temperature cause excessive condensation. Fungus has a considerable hand in increasing and maintaining moisture deposits, and hence aggravating corrosive action. That it also causes chemical changes in insulation and other organic materials is generally admitted, but it is impossible to draw sharply any line of demarcation between the effect of moisture alone and the acceleration due to fungus.

Extensive tests made in the laboratory and correlated with outdoor exposure in Florida swamps show that moisture proofing is of the utmost importance, but that biological factors must not be neglected. A few laboratories have made accelerated tests without this correlated exposure and the results do not bear out actual conditions.

In surroundings like this far cry from the placid corner of a living room, moisture and fungus treatment of a radio may make the difference between hours and months of maintenance-free operation

TABLE I. VULNERABILITY OF COMMON MATERIALS TO FUNGUS ATTACK

Most vulnerable: Cellulose, cement, cordage, cotton, felt, glue, leather, paints, phenolics, paper, varnish, varnished cambric, and waxes (most)

Less vulnerable: Melamine, rubber (natural and synthetic), and waxes (micro-crystalline)

Least vulnerable: Glass (clean), glass fiber, inorganics, polystyrene, and polyvinylidene chloride

Severity of Service

In the field of electrical and electronic equipment, extensive service in foreign countries and in temporary quarters has brought about environmental conditions quite different from peacetime ones. Particularly in the case of electronic equipment which in pre-war years was normally well sheltered, the whole technology of manufacturing components and assemblies grew up with no severe service conditions or exposure background. The early days of the war found American industry hastily multiplying its production many times and, in the main, following previous commercial and civilian practices.

It should be emphasized that actual field conditions in many cases are as severe as our previous ideas of accelerated tests. For example, it used to be considered a severe test to expose components to 10 days of high humidity and high temperature, that is, 90 to 95 percent relative humidity at 100 deg F. While the temperature may be a

few degrees high for field conditions, it is certainly no accelerated test as far as humidity goes. A minimum of 30 days exposure to such conditions may be normal for any extensive campaign.

Frequent rainfall in many parts of the world, rapid temperature cycles with extremes—both high and low—all occur in the life of equipment. Every factor in equipment design, outside the electrical functioning, has been inadequate to some degree for the rigorous service occuring in military operations.

It is more or less customary for engineers to treat corrosion deterioration and service degradation as though they all took place in a sterile environment—one totally free of organic life forms and to a considerable extent as though it were free of organic debris.

Actually, the most casual inspection of any surface would indicate three common phenomena: (1) lodgment of air-moved organic dust; (2) presence of micro-organisms in large quantities—either in the form of spores or in the form of colonial and active growths; and (3) presence of insects and other living forms with their inevitable residue of mucus or non-living organic matter. Also present are inorganic dirt, dust, and debris; condensed and absorbed moisture; and specific chemical salts.

In great measure, degradation depends on conditions of moisture, temperature and light but microorganisms on any given surface may produce any of several effects. By their mere presence, they may produce paths of low electrical resistance and no further damage. However, during the course of their life cycle, they may produce electrolytes which augment corrosion of the base or deteriorate certain porous insulation surfaces.

As a third alternative, they may particularly and specifically deteriorate organic material, leading to such outstanding examples as the destruction of cellulosic materials by *chaetomium globosum* and other species. In addition, there occurs a chain of attendant effects hard to distinguish and isolate. These include: (1) retention of moisture on surfaces that would normally dry out more quickly; (2) increased wetting of relatively non-wettable surfaces; or (3) establishment of osmotic-equilibrium conditions favoring solution of metals.

Materials of Construction

PHENOLICS, both molded and laminated, absorb water at a rapid rate. This causes leakage paths and at times, swelling to such an extent that molded pieces may crack and laminates become separated. Several methods of phenolic protection have been devised whereby the rate of moisture absorption can be reduced to a minimum.

Normal spray equipment is used in fungus-proofing procedures. Regulations requiring booths and ventilating systems are generally regarded as adequate for toxicant-bearing finishes as well as conventional types

For instance, air-dry lacquers generally have poor adhesion to phenolic parts. An air-dry varnish is more successful for this application, but by the very nature of a phenolic surface, a baked-on finish is the only type that really provides a reasonably permanent coating. As an alternative treatment, impregnation with a fungistatic wax compound has proved more water-resistant than a baked-on finish. Fungicidal concentrates that may be added to standard waxes are obtainable in various forms. However, where resistance to surface-arcing is necessary, the baked finish should be used.

Wax-filled or wax-coated components are frequent sources of breakdown from fungus attack. This difficulty may be alleviated by using a fungicidal wax at the time of manufacture or else giving the part a flash dip in a similar compound before incorporation in the equipment. Inasmuch as there is extremely poor adhesion to a waxed surface by either lacquer or varnish, using the fungicidal wax is the safer and more lasting method.

FIBER PIECES react to moisture in a manner similar to phenolics, with the additional problem of extreme fungus attack. They may be well protected by either a baked coating or by wax impregnation—both containing fungicides.

TEXTILE-COVERED CORDS and cables require treatment for a dual purpose—they must be made water-repellant and fungistatic. If this were not done, the electrical resistance would drop below the point of operating efficiency in an amazingly short time. The Signal Corps has approved materials for this purpose which provide excellent service.

LEATHER is another material requiring treatment for both water repellance and fungus-proofing. The Signal Corps has developed a solution which can be purchased, ready for use, from manufacturers and which is easy to apply.

FELT, which unfortunately cannot be water-proofed without changing its characteristics, can nevertheless be fungus-proofed. Felt manufacturers provide their product already finished, but where there are stocks on hand, fungicidal preparations can be applied.

CERAMIC PIECES should be glazed, or where this is impossible, must be wax-impregnated with a fungicidal wax.

LACING CORDS for use in wire-harnesses should be impregnated with a fungicidal wax.

DYNAMOTORS AND GENERATORS have occasioned considerable difficulty primarily through corrosion, and only moderately through fungus attack. It is therefore recommended that armature and field

coils be varnish impregnated and dip coated as usual, but instead of applying an air-dry sealer over the primary insulation, there be substituted a baking compound that retains its fungistatic properties after the baking process. There are such products approved by the Signal Corps and now in use to a considerable extent. All other circuit elements in the dynamotors should be sprayed according to specification No. 71-2202A.

HOOK-UP WIRES offer a considerable problem due to the fact that ordinary lacquers and varnishes attack the lacquer finish with which the wires are coated by the manufacturer. One lacquer approved by the Signal Corps does not attack this coating, and dries in a few minutes. The wires should be dipped in this product before incorporation in the set.

Actual exposure of test panels in tropical climate is used by the Insl-X Co. to correlate laboratory work with field results. Full-scale equipment runs are made under the same conditions

Treatment

Probably only a small percentage of our equipment failure can be blamed solely on biological factors. Nevertheless, not to do anything about this percentage of failure would be as negligent as to overlook any other factor.

Knowledge gained from research and practical field work accomplished in the past two years should serve industry well in the period of reconstruction which must take place in occupied countries when Japanese domination ends. Equipment manufacturers who have an eye on Eastern export trade after the war will, by study of tropicalization requirements, find a means of providing goods that will be able to cope with prevailing conditions.

In certain sections of our own country and in South America similar conditions prevail, and certain practical adaptations of tropicalization prove advantageous on all equipment.

The methods presently adopted by our Armed Forces have increased the life of electronic equipment from a few days to many months, providing, of course, that the component parts selected by the manufacturer for inclusion in the apparatus are of good quality.

Under the existing program, the prime contractor may order his material from the sub-contractor with the proper treatment already applied. Furthermore, in several sections of the country, organizations have been set up to handle all tropicalization requirements up to final assembly.

Tropicalization of electronic equipment must, of necessity, be divided into two sections: (1) The protection of component parts and (2) Overall sprays. The general intent of Signal Corps Specification No. 71-2202A is to provide a treatment for assembled equipment only. Component parts should be treated separately according to a number of supplementary recommendations issued by Fort Monmouth Signal Laboratory. Films entirely suitable as protection for completed equipment are by their very nature not satisfactory on a number of components.

One of the problems connected with the application of Specification No. 71-2202A is ascertaining the simplest method by which complete coverage can be achieved. It has been found by many manufacturers that the surest method is to spray each sub-assembly separately; this enables the sprayer to coat rear sections which are inaccessible in the complete assembly. When the entire set is assembled, practically all that then need be done is touch up the connections.

At present there is no method of verifying the completeness of treatment given an assembly. However, a program to be adopted will include the addition of fluorescent dyes to the coating materials so inspection can be performed under infrared light.

Tests prove that lacquers and varnishes developed for overall sprays must be designed so that the ultimate in moisture resistance is provided. Moisture resistance of any organic insulation film is generally evaluated in the laboratory on the following properties:

I. Electrical
   - Dielectric Strength (Wet).
   - Insulation Resistance (Wet).

II. Physical
   - Resistance to high temperatures.
   - Resistance to low temperatures.
   - Resistance to high- and low-temperature shock.
   - Adhesion to various surfaces—metal and non-metal.

III. Moisture Vapor Permeability
   - Resistance to migration of water capor under the conditions of high tem-

perature and humidity.

IV. Corrosion Resistance
Resistance of the organic system coated over a metal panel to immersion either in salt or fresh water or to salt-water spray tests.

If the organic system in question, with or without a fungicide, will give good values when tested for the various properties mentioned above, such a system may be considered moisture resistant and definitely good insulation.

Lacquer or Varnish

Lacquer and varnish systems each have their specific points of advantage, and selection of the most suitable coating can be made from the following comparison of factors:

DRYING. A lacquer, generally speaking, dries by simple evaporation of solvent, and the rate of through-film drying is determined by the volatility of the solvents. Solvents can be alcohols, esters, ketones, ethers, or hydrocarbons. Drying time tack-free as short as a minute is possible, although not generally advisable.

A varnish generally dries in two phases. First, an evaporation of solvent, followed by further polymerization and frequently oxidation. Only very short varnishes with high resin content dry tack-free in 15 minutes to an hour, and through-drying generally takes 4 hours and longer. This slow through-drying means difficulty in applying a second coat. Also, the short varnishes that dry rapidly require a high percentage or all of the solvent to be aromatic hydrocarbons which possess strong solvent power.

Lacquer solvents are also high in solvent power but due to their faster release from a lacquer film generally can be adjusted to cause less effect on undercoats of organic materials. Most lacquers are available with alternate solvent formulas to keep solvent effect at a minimum.

FLEXIBILITY. Varnishes in general are relatively hard—the shorter the harder, and they generally increase in hardness with age. Lacquers can be made with any degree of flexibility and distensibility and while they may lose flexibility with age, they lose it at a much slower rate than varnishes.

ADHESION. Varnishes—particularly short varnishes—exhibit good adhesion but lacquers can be formulated to produce adhesion to a much greater variety of surfaces.

LOW-TEMPERATURE CHARACTERISTICS. Varnishes—particularly short oil varnishes—become brittle at low temperatures and may lose adhesion on a great variety of surfaces. Lacquers, on the other hand, can be formulated to have initially better flexibility and to retain a much better low-temperature adhesion.

HIGH-TEMPERATURE CHARACTERISTICS. Varnishes withstand high temperatures better than lacquers since they are thermosetting and may improve with heating, to a point—after which they heat-age rapidly. Continued heating above a certain temperature is destructive.

Lacquers are generally thermoplastic and soften with heat but reharden on cooling without damage. Continued heating may harden or toughen the film but below the decomposition point continued heating does no permanent damage.

VAPOR PERMEABILITY. Generally, the short oil varnishes have lower rates of vapor permeability than lacquers.

Types of Fungicides

The question then arises as to the type of fungicide to be used—with special consideration to the volume required. It would seem evident that the fungistatic agent that gives the greatest protection with the least quantity, providing all other factors are given consideration, should be the one which will least disturb the structure of the coating.

Three materials have been generally accepted as providing good fungistatic properties. These are:

(1) Phenyl mercuric salts
(2) Pentachlorphenol
(3) Salicylanilide

Acceptable minimums for use in lacquers and varnishes are as follows: Phenyl mercuric salts—1 percent, Pentachlorphenol—15 percent, Salicylanilide—10 percent.

Besides quantity, another important consideration is longevity of the toxicant. Naturally, the use of a product that displays excellent general inhibitive value for the first month or two is of little value when, as a rule, electronic equipment is in storage for several months before it even reaches the field, frequently under hot and humid conditions.

The question of toxicity to personnel has been brought up many times. It is generally agreed that the customary risk of dermatitis from the use of lacquers and varnishes is not increased by addition of any of the three presently used toxicants. The laws of most states require that spray booths and ventilating systems be employed when using lacquers and varnishes, and if proper methods are followed no ill effects should result.

Perhaps the most controversial matter in the whole subject of tropicalization is the effect on selenium rectifiers of lacquers and varnishes containing phenyl mercuric salicylate. There is no doubt that mercury vapors affect uncoated selenium disks, but tests run by one of the best qualified independent laboratories in the country show that in 1500 hours of operation a number of uncoated selenium rectifiers dipped directly in a lacquer containing phenyl mercuric salicylate showed no degradation. On the other hand, Signal Corps tests showed that in sealed containers breakdown occurred. The correct answer may involve agreement on proper test methods, purity of the phenyl mercuric salt, reaction of the lacquer or varnish with the toxicant, and development of a satisfactory moisture-proof coating for rectifiers.

Spore Tests

It is known that the fungus tests now used for acceptance under Specification No. 71-2202A may not be entirely representative of actual conditions and it has been suggested that more than one organism should be used in any evaluated fungus tests. Of the three common fungicides only phenyl mer-

curic salicylate will pass both a mixed-spore and a single-spore test. Until such time as a means is created to show that this test can be correlated to field exposure, these present requirements should, for safety's sake, be followed.

On area of inhibition, one other consideration is life of the fungicide when subjected to operating temperatures of equipment and natural dissipation through volatilization. Table II shows fungistatic value of the three selected fungicides after exposure to various temperatures, and using both a single spore and a spore mixture.

Micro-Organisms

Under the general classification of those organisms so small that a microscope is required for their study are:

(1) *Protozoa*, uni-cellular animals, many of them living in water and obtaining their food from organic material. A large number utilize other micro-organisms.

(2) *Molds*, a sub-division of the fungi group.

(3) *Yeasts*.

(4) *Bacteria*, these are normally considered the smallest and lowest of all forms of life. Undoubtedly some are below visibility even with the highest magnification of an optical microscope.

(5) *Algae*, micro - organisms which possess chlorophyll—these are aquatic.

Some authorities divide the fungi into three main divisions, starting with the bacteria as generally covering the smallest in size, the *actinomyetes* intermediate, and largest, the various fungi species forming colonies visible to the eye.

A true conception of the number and rapidity of growth of these organisms is not common in the engineering world. It is difficult to look at a few drops of transparent water and realize the infinite number of living organisms present. It is even more difficult to realize the complex, intricate, and never-ending cycle of life taking place in such a small quantity of material.

For example, normal surface sea water contains as many as a million micro-organisms per cc. Every time a wave breaks, there are thrown into the air untold numbers of marine bacteria, some of which are carried hundreds of miles, still viable and capable of growth and multiplication as soon as suitable conditions arise.

We are only now getting some inkling of the ability of micro-organisms to utilize organic materials for energy. During the past two years, Dr. Zobell at Scripps Institute has found that many of the marine bacteria are capable of oxidizing pure hydro-carbons. Specifically, certain species have been isolated as able to utilize gasoline, paraffin, benzene, toluene, paradichlorbenzene and others. The same investigator likewise found that rubber and synthetic rubber could be destroyed by the presence of certain bacteria.

It is likely that as investigations in this field progress, we will find that many organic materials are particularly susceptible to deterioration by individual species. It will then be more expedient to protect the material against these specific agents than against the broad classification.

Bibliography

McAuley, P. H., "Heating of Equipment for the Prevention of Condensation," Engineering Data Letter No. 1314, Engineering Labs and Standards Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

"Symposium on Mildew Resistance," American Society for Testing Materials, 260 South Broad St., Philadephia, Pa.

Lawson, Francis R., "Causes and Control of Deterioration of Material in the Wet Tropics," ADTIC Project No. T-25, Arctic, Desert, and Tropic Information Center, Orlando, Fla.

Coursey, Philip R., Extreme Climatic Conditions, *Wireless Engineer*, London, England, Sept. 1944.

"This is Serious", Reproduction Section, Fort Monmouth Signal Laboratory, Red Bank, N. J.

Gardner, D. H.; and Watt, J. S., "Difficulties Encountered with Electronic Equipment in Humid Climates", Second Edition, 1944, Humble Oil & Refining Co., Houston, Tex.

"The Effects of Moisture on the Electrical Operation of Communication Equipment Used in the Tropics and Possible Control", Bell Telephone Laboratories, New York, N. Y.

"Mould in Radio & Signals Equipment—Tropical Reports No. 1", Amalgamated Wireless (A'sia) Ltd., N. S. W.; Australian Military Mission, 4516 Munitions Bldg., Constitution Ave., Washington, D. C.

"Standard Packaging for Signal Corps Equipment", Signal Corps Specification No. 72–0–7, Plans & Operations Division; Specification & Distribution Section: Philadelphia Signal Corps Procurement District: 128 North Broad St., Philadelphia, 2, Pa.

"Report on the Condition of Service Material under Tropical Conditions in New Guinea"; Australian Scientific Research Liaison Office, Washington, D. C.

TABLE II. FUNGISTATIC VALUES

IN A VARNISH SYSTEM

TEMPERATURE: 85 DEG C *TIME: 2 HR*
(Specification No. 71-2202A)

Toxicant	Percent Toxicant *	Single Spore Test**	Spore Mixture Test***
Phenyl Mercuric Salicylate	1	OK	OK
Pentachlorphenol	10	NG	NG
Pentachlorphenol	15	OK	NG
Salicylanilide	10	OK	NG
Salicylanilide	15	OK	NG

TEMPERATURE: 85 DEG C *TIME: 24 HR*

Phenyl Mercuric Salicylate	1	OK	OK
Pentachlorphenol	10	NG	NG
Pentachlorphenol	15	NG	NG
Salicylanilide	10	OK	NG
Salicylanilide	15	OK	NG

TEMPERATURE: 130 DEG C *TIME: 2 HR*

Phenyl Mercuric Salicylate	1	OK	NG
Pentachlorphenol	10	NG	NG
Pentachlorphenol	15	NG	NG
Salicylanilide	10	NG	NG
Salicylanilide	15	NG	NG

TEMPERATURE: 130 DEG C *TIME: 5 HR*

Phenyl Mercuric Salicylate	1	OK	NG
Pentachlorphenol	10	NG	NG
Pentachlorphenol	15	NG	NG
Salicylanilide	10	NG	NG
Salicylanilide	15	NG	NG

IN A LACQUER SYSTEM

TEMPERATURE: 85 DEG C *TIME: 2 HR*
(Specification No. 71-2202A)

Phenyl Mercuric Salicylate	1	OK	OK
Pentachlorphenol	10	OK	NG
Pentachlorphenol	15	OK	NG
Salicylanilide	10	OK	NG
Salicylanilide	15	OK	NG

TEMPERATURE: 85 DEG C *TIME: 20 HR*

Phenyl Mercuric Salicylate	1	OK	OK
Pentachlorphenol	10	NG	NG
Pentachlorphenol	15	NG	NG
Salicylanilide	10	OK	NG
Salicylanilide	15	OK	NG

TEMPERATURE: 50 DEG C *TIME: 96 HR*

Phenyl Mercuric Salicylate	1	OK	OK
Pentachlorphenol	10	NG	NG
Pentachlorphenol	15	NG	NG
Salicylanilide	10	OK	NG
Salicylanilide	15	OK	NG

TEMPERATURE: 100 DEG C *TIME: 8 HR*

Phenyl Mercuric Salicylate	1	OK	OK
Pentachlorphenol	10	NG	NG
Pentachlorphenol	15	NG	NG
Salicylanilide	10	NG	NG
Salicylanilide	15	NG	NG

*Based on total weight.
**Aspergillus Niger.
***Aspergillus Niger, Penicillium Luteum, Actinomycetes Convolutus, and Rhizopus Nigricans.

Coaxial Cable D

Exact and approximate formulas for determining basic parameters of coaxial cable facilitate determining effects of conductors, dielectrics and dimensions on electrical characteristics. Graphs indicate variations that can be expected from changes in materials and construction

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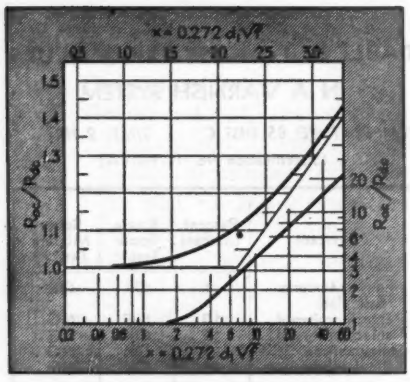


FIG. 1—Skin effect resistance factor for solid round copper wire

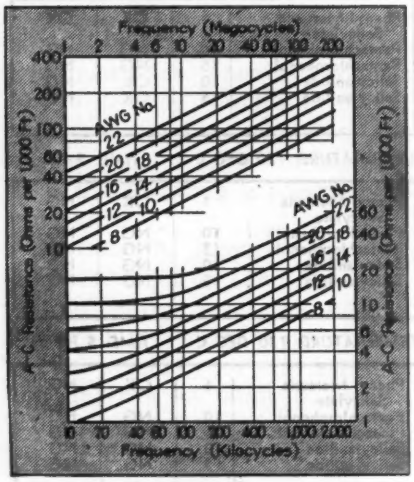


FIG. 2—Alternating-current resistance of solid round copper wire

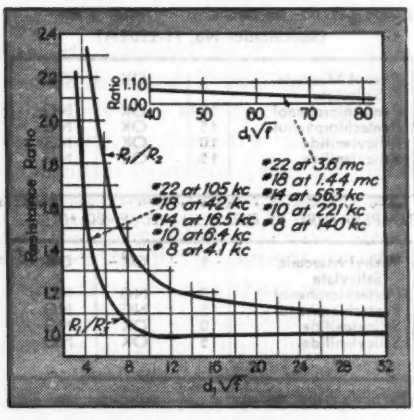


FIG. 3—Relative errors of Eq. (3) and (4) compared to values obtained from Fig. 1

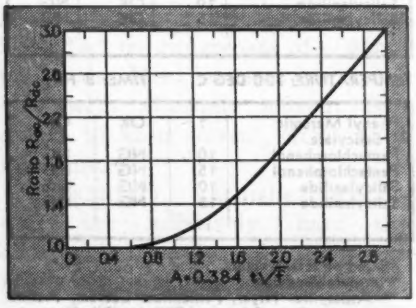


FIG. 4—Relative inside a-c resistance of the concentric conductor

DESIGN AND USE of coaxial cable at radio frequencies requires a knowledge of the cable parameters and the manner in which they vary with cable construction and operating frequency. Exact equations are cumbersome, but within limits they can be simplified for use in design or in obtaining approximate indications of the major influences on cable parameters.

Basic parameters which determine characteristic impedance, attenuation and phase-shift constant of coaxial cable are series resistance and inductance, and shunt capacitance and conductance. These parameters are functions of the electrical characteristics of the material used for conductors and dielectric, the geometric design of component parts and the frequency at which the cable is to operate.

Series Resistance

Total series resistance (R_o) of a coaxial cable consists of two components: resistance of the center conductor and of the concentric conductor.

Formulas for determining resistance of a solid round-center conductor at any frequency have been published in text books and technical papers. However, these formulas, which involve Bessel functions, are complicated and do not lend themselves to rapid calculations. Fortunately for the design engineer there have been published in the Bureau of Standards' Circular No. 74 tables of the ratio of resistance at any specified frequency to the d-c resistance for round solid conductors as a function of diameter and frequency. Resistance ratios are presented in graphic form in Fig. 1 for round solid copper wire having a resistivity (ρ) of 1724 abohm-centimeters as a function of x, the skin-effect resistance factor

$$x = 0.272\, d_1 \sqrt{f} \qquad (1)$$

which is derived from

$$x = \pi d_1 \sqrt{2\mu f/\rho} \qquad (2)$$

where μ = magnetic permeability of the conductor.

Resistance (R_1) of various sizes of conductors in the frequency range of 10 kilocycles to 400 megacycles, as determined from the ratio curve, is plotted in Fig. 2.

Note that the resistance ratio curve (Fig. 1) is practically a straight line for values of x greater than 5. This permits the determination of the following approximate equations for the straight-line portions of the curve

$x > 4$

$$R_2 \sim 0.284\, R_{dc} + 0.993\, \sqrt{f}\, 10^{-3}/d_1 \text{ ohms/1000 ft} \qquad (3)$$

$x > 10$

$$R_3 \sim 10^{-3}\, \sqrt{f}/d_1 \text{ ohms/1000 ft} \qquad (4)$$

where $R_{dc} = 0.01037/d_1^2$ ohms/1000 ft (5)

It is very important to the design engineer to be able to utilize at all times the simplest formula possible. Variations in magnitude of the resistances as calculated by the above methods for various sizes of conductors at different frequencies are plotted in Fig. 3 as ratios of R_1/R_2 and R_1/R_3. Figure 3 also shows frequencies at which resistance limitation ratios are not greater

than 1.05 for several sizes of conductor. Which of the three methods to use for calculating resistance of a solid round inner conductor depends upon the accuracy required.

Resistance of Stranded Conductors

In a large number of coaxial cables the inner conductor consists of several strands. Resistance calculated by any of the mentioned methods will give values lower than those actually measured. Unfortunately at present there is not enough data to evaluate the increase in resistance for a stranded conductor as compared to a solid conductor of the same area and diameter.

Bureau of Standards' Circular No. 74 suggests as a rough guide that the resistance ratio of strands of bare wires placed parallel and making contact with one another is the same as for a round solid wire which has the same area of cross-section as the sum of the cross-sectional areas of the strands. However, when a precise knowledge of the resistance ratio is required it should be measured. The following tentative rules are suggested as a guide to the behavior of a stranded conductor. (1) An increase in the number of strands for a given total area of copper increases high-frequency resistance. (2) For a given total area of copper and number of strands, a conductor cabled with strands having a long lay will have a slightly lower high-frequency resistance than for an equivalent conductor having a short lay.

Concentric Conductor

The concentric conductor of a coaxial cable has two functions: to act as a shield and to act as a conductor. The resistance of a concentric conductor when it consists of a thin-wall tube may be determined from formulas which have been published by Whinnery.

Figure 4 is a plot of the ratio of resistance of a concentric copper cylinder at any frequency to d-c resistance as a function of

$$A = t/y = 0.384\, t\, \sqrt{f} \qquad (6)$$

where

t = wall thickness of outer conductor in inches

y = depth of field penetration in inches

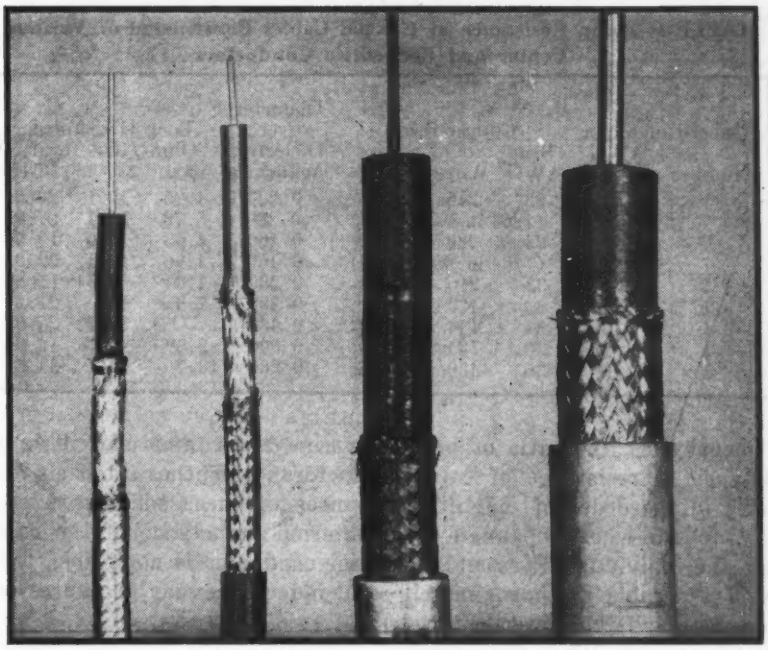
when the inside diameter d_2 of the cylinder is at least ten times the wall thickness (t).

When the parameter (A) is greater than 3, the resistance of this type of concentric conductor may be expressed as

$$R \sim 10^{-3}\, \sqrt{f}/d_2 \text{ ohms/1000 ft} \qquad (7)$$

Most coaxial cables utilize a copper braid for the concentric conductor. At present, as far as the author knows, no formulas permit calculation of high-frequency resistance for this type of concentric conductor. However, tests have indicated that the following tentative rules apply: (1) Resistance of braided concentric conductor decreases with an increase in length of lay of individual strands of the braid. (2) For braid having a given lay, an increase in the number of strands decreases resistance. (3) For braid of a given percent coverage an increase in size of the individual strands causes a decrease in resistance. (4) Resistance of a given braid will increase when individual wires are corroded. (5) Resistance of a given braid will vary with variations in contact pressure between strands.

In the frequency range of 100 to



Typical coaxial-cable construction employing solid dielectrics

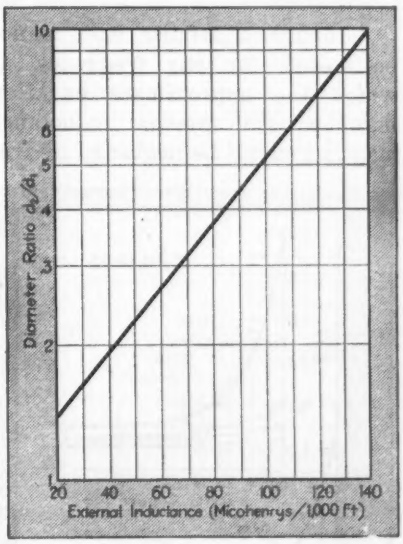


FIG. 5—Inductance from field between conductors of coaxial cable

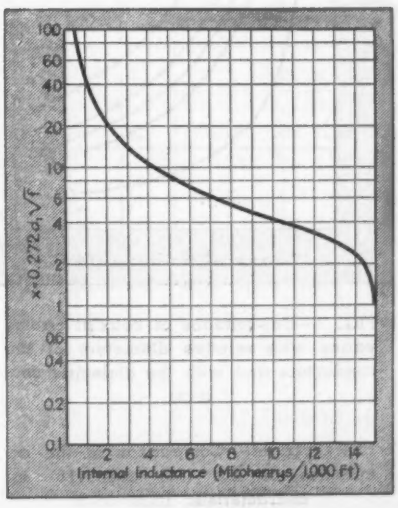


FIG. 6—(right) Inductance from field within center coaxial conductor

TABLE I—Loop Resistance of Coaxial Cables Constructed of Various Center and Concentric Conductors

Inner Conductor Number	Inner Conductor AWG No.	Copper Braid Size AWG	Copper Braid No. of Wires	Copper Braid Lay Inches	Diameter over Dielectric in Inches	Loop Resistance Ohms/1000 ft. at 50 kc	Loop Resistance Ohms/1000 ft. at 300 kc	Loop Resistance Ohms/1000 ft. at 1 Mc
7	21	33	216	1.55	0.280	4.95	12.1	20.6
7	21	(4/64 in. wall Lead)			0.280	5.78	16.1	27.9
7	21	33	288	1.60	0.460	4.65	10.6	19.6
7	21	(4/64 in. wall Lead)			0.460	4.96	13.1	22.8
1	12	33	216	1.72	0.280	4.84	9.54	17.5
1	12	33	120	0.50	0.280	7.3	16	27.2
1	12	34	144	0.57	0.489		14.7	26.6
1	9	30	384	4.00	0.690	2.39	6.76	12.0
1	18	36	480	1.26	0.280	10.7	19.1	34.8

400 megacycles, the ratio of braid resistance to resistance of copper tube is in the order of magnitude of 2.5 to 4.5 when the angle between the individual wires and the axis of the cable is approximately 25 degrees and the coverage is at least 90 percent. When the coaxial cable consists of a stranded inner conductor and a copper braid for the concentric conductor, the only accurate method of obtaining total resistance at any frequency is by accurately measuring that combination of conditions. Table I lists measured resistances of several combinations of inner and outer conductors.

Series Inductance

Total inductance (L_0) of coaxial cable consists of the inductance between center and concentric conductors, and the internal inductances of these conductors. Since internal inductance of the concentric conductor is negligible, the total inductance may be expressed as

$$L_0 = L_e + L_i = [0.140 \log_{10} (d_2/d_1) + 0.015 (L_{ac}/L_{dc})] \times 10^{-3} \text{ henrys/1000 ft} \quad (8)$$

L_{ac}/L_{dc} = ratio of L_i at a-c conditions to L_i at d-c conditions

The external inductance term (L_e) of the total inductance is plotted in Fig. 5 as a function of the ratio of diameter under the concentric conductor to diameter over the center conductor. Figure 6 shows graphically the internal inductance (L_i) of the center conductor. This inductance decreases with an increase in frequency and/or an increase in diameter.

At frequencies so high that the internal inducance term $0.015\ L_{ac}/L_{dc}$ may be neglected, the total inductance may be simplified to

$$L_0 = L_e = 0.1404 \times 10^{-3} \log_{10} (d_2/d_1) \text{ henrys/1000 ft} \quad (9)$$

Although a definite rule cannot be stated for the frequency at which the approximate equation may be used, internal inductance may in general be neglected at frequencies greater than 2 Mc. A comparison of measured and calculated inductance for coaxial cables having a center conductor consisting of seven strands of copper indicates that for that type of conductor a better agreement between theoretical and measured values is obtained when the diameter over the center conductor is assumed to be equal to the square root of the circular mil area.

Shunt Admittance

Shunt capacitance (C) depends upon the ratio of diameter under the concentric conductor to the diameter over the center conductor, and the effective dielectric constant (K) of the insulating material. If the dielectric constant varies with frequency, there will be a direct change in capacitance. Fortunately most dielectrics are relatively constant with frequency. The formula for the capacitance is

$$C = \frac{7.36\,K\,10^{-9}}{\log_{10} (d_2/d_1)} \text{ farads/1000 ft} \quad (10)$$

Variations in the capacitance as a function of (K) and the ratio of diameters are shown graphically in Fig. 7. An accurate knowledge of capacitance is important due to its effect on characteristic impedance, as will be shown later.

Shunt conductance (G) depends upon frequency, capacitance and dissipation factor of the insulating material and may be determined from

$$G = \omega DC \text{ mhos/1000 ft} \quad (11)$$

Of the terms in this expression, capacitance remains essentially constant with frequency; the dissipation factor (D) of the dielectric may vary considerably. Since conductance loss contributes increasingly to attenuation with increasing frequency, it is very important that the dissipation factor be accurately known for the frequency at which conductance is to be determined.

Characteristic Impedance

The user of coaxial cables, such as the designer of high frequency equipment or a radio transmission engineer, is not so much interested in the cable's basic parameters as in the operating parameters, which are characteristic or surge impedance, attenuation, and phase-shift.

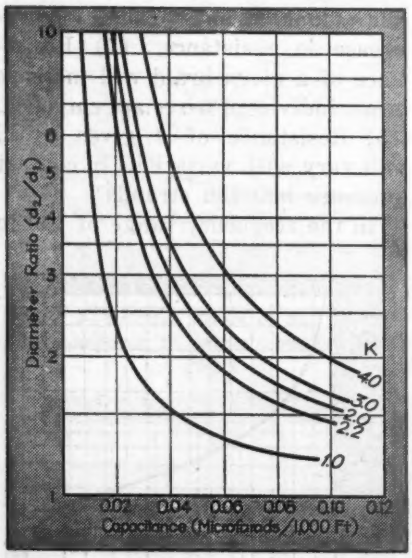


FIG. 7—Capacitance of coaxial cables varies with relative diameters of the conductors and with the dielectric constant

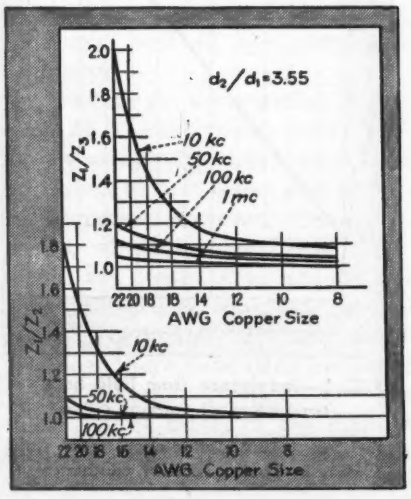


FIG. 8 (right)—Comparison of the accuracies of Eq. (14) and (15) for characteristic impedance

Characteristic impedance (Z_0) is that impedance which, terminating a line, will theoretically reduce reflection losses to zero. In practice ideal conditions may not be realized, but nevertheless a line terminated in its characteristic impedance will have a minimum reflection loss. Coaxial cables in the radio-frequency range and higher are normally designed to have a characteristic impedance of 50 ohms or 70 ohms.

This parameter may be determined at any frequency from

$$Z_0 = \sqrt{\frac{R_0^2 + (\omega L_0)^2}{G^2 + (\omega C)^2}} \text{ ohms} \qquad (12)$$

Where R_0 = total resistance in ohms/1000 ft.

Experience has shown that this equation is more flexible when written as

$$Z_0 = \sqrt{\frac{\sqrt{R_0^2 + (\omega L_0)^2}}{\omega C \sqrt{D^2 + 1}}} \text{ ohms}$$

As dielectrics utilized in coaxial cables have power factors considerably less than 5 percent, the term $\sqrt{D^2 + 1} \sim 1$, hence

$$Z_1 \sim \sqrt{\frac{\sqrt{R_0^2 + (\omega L_0)^2}}{\omega C}}$$

$$\text{or} \quad Z_1 \sim \sqrt{\frac{L_0}{C}} \sqrt{\left[\frac{R_0}{\omega L_0}\right]^2 + 1} \text{ ohms} \qquad (13)$$

When R_0 is very small as compared to ωL_0 Eq. (13) may be simplified to

$$Z_2 \sim \sqrt{L_0/C} \text{ ohms} \qquad (14)$$

When the frequency is such that the internal inductance L_i may be neglected the characteristic impedance can be determined from a very simple equation

$$Z_3 = \sqrt{L_e/C} = (138/\sqrt{K}) \log_{10}(d_2/d_1) \text{ ohms} \qquad (15)$$

No definite rule can be made as to the frequency range in which the approximate equations may be used due to the variables involved. However, as a guide to their limitations the impedance ratios Z_1/Z_2 and Z_1/Z_3 as a function of frequency and diameter of the center conductor are plotted in Fig. 8.

These ratios were determined for coaxial cables having a ratio of $d_2/d_1 = 3.55$, a round solid copper center conductor, and a copper-tube concentric conductor. The dielectric medium was assumed to have a dielectric constant of 2.3 and a dissipation factor of 1.0 percent. For other diameter ratios there are corresponding changes in the limitations of the approximate formulas.

It is interesting to note that the accuracy of the impedance formulas is independent of dielectric constant for a given ratio of d_2/d_1

$$Z_1/Z_2 = \sqrt[4]{(R_0/\omega L_0)^2 + 1} \qquad (16)$$

$$Z_1/Z_3 = \sqrt{1 + (L_e/L_i)} \times \sqrt[4]{(R_0/\omega L_0)^2 + 1} \qquad (17)$$

$$Z_2/Z_3 = \sqrt{1 + (L_e/L_i)} \qquad (18)$$

Because characteristic impedance is a function of the diameter ratio d_2/d_1 and the dielectric constant, it is of considerable aid in designing a cable for a given impedance to know the effects of variations in these components due to manufacturing limitations and the dielectric to be used. Such variations may be easily studied by means of a graph as in Fig. 9 for the frequency range in which impedance may be expressed by Eq. (15). Furthermore this graph may be used in making first approximations of the ratio d_2/d_1 for frequencies in which the impedance may be determined from Eq. (14).

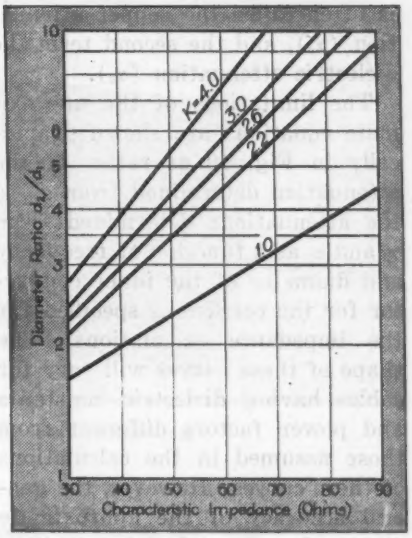


FIG. 9—Dependence of characteristic impedance on dielectric constant and diameter ratio

TABLE II—Symbols for coaxial cable parameters and the equation or figure in which they are presented

- a_0 —Attenuation constant of cable: Eq. (19)
- a_1, a_2, a_3—Alternate forms of a_0: Eq. (20), (21), (22)
- a_c —Attenuation due to loss in conductor: Fig. 12
- a_d —Attenuation due to loss in dielectric: Fig. 12
- β_0 —Phase-shift constant of cable: Eq. (23)
- β_1, β_2—Alternate forms of β_0: Eq. (24), (25)
- C —Shunt capacitance of cable: Eq. (10); Fig. 7
- D —Dissipation factor of dielectric
- d_1 —Outside diameter of center conductor
- d_2 —Inside diameter of outside conductor
- G —Shunt conductance: Eq. (11)
- K —Dielectric constant of coaxial dielectric
- L_0 —Total series inductance of cable: Eq. (8)
- L_e —External-inductance component of L_0: Fig. 5
- L_i —Internal-inductance component of L_0: Fig. 6
- R —Approximate a-c resistance of outer conductor: Eq. (7); Fig. 4
- R_0 —Total series loop resistance of cable: $R + R_1$
- R_1 —A-C resistance of center conductor: Fig. 1 & 2 Alternate forms for limited ranges are given by Eq. (3) & (4)
- V —Velocity of wave in cable: Eq. (27)
- V_0 —Velocity of wave in free space (984 $\times 10^6$ ft/sec)
- x —Skin effect resistance factor: Eq. (2); Fig. 1
- Z_0 —Characteristic impedance of cable: Eq. (12)
- Z_1, Z_2, Z_3—Alternate forms of Z_0: Eq. A(13), (14), (15)

Attenuation

Attenuation of coaxial cable at any frequency may be determined from

$$a_0 = 6.14 \sqrt{\sqrt{[R_0^2 + (\omega L_0)^2]\,[G^2 + (\omega C)^2]} + (GR_0 - \omega^2 L_0 C)} \text{ decibels/1000 ft} \qquad (19)$$

This equation can be written in a more practical form by grouping terms

$$a_1 = 6.14 \times \sqrt{\omega C[\omega L_0(\sqrt{(R_0/\omega L_0)^2+1}\sqrt{D^2+1}-1)+DR_0]} \text{ decibels/1000 ft} \qquad (20)$$

Note that variations in attenuation due to variations in basic parameters are more clearly seen from a study of Eq. (20) than Eq. (19). At high frequencies the attenuation formula may be simplified to

$$a_2 \sim 4.34\,(R_0/Z_1 + GZ_1) \qquad (21)$$

When the frequency and size of the inner conductor are such that the impedance can be expressed by Eq. (15), a further simplification may be made

$$a_3 \sim \sqrt{K}\left[\frac{0.0315\,R_0}{\log_{10} d_2/d_1} + 27.7\,f\,D\,10^{-6}\right] \text{ decibels/1000 ft} \qquad (22)$$

The first term of these equations

is often called the copper attenuation (α_c), and the second term the dielectric attenuation (α_d).

The limitations of the approximate equations are shown graphically in Fig. 10 as ratios of the attenuation determined from α_1, to the attenuations determined from α_2 and α_3 as a function of frequency and diameter of the inner conductor for the conditions specified for the impedance calculations. The shape of these curves will vary for cables having dielectric constants and power factors different from those assumed in the calculations of these curves. However, the general accuracy of the approximate attenuation formulas is as indicated.

Effect of Dielectric

The effect of the dissipation factor of the dielectric on attenuation is very important. This can be seen graphically in the attenuation vs frequency curves shown in Fig. 11 for a No. 8 solid copper center conductor, 0.020-inch wall copper sheath and a dielectric constant of 2.3. The dielectric is assumed to have a dissipation factor of either 0.1 percent or 1.0 percent. For simplification of calculations, attenuations were determined from α_2.

Note that the dissipation-factor effect increases with frequency and either the attenuation due to the copper or to the dielectric may predominate. It has been found of considerable aid in designing coaxial cables to construct graphs similar to those in Fig. 12 for α_c and α_d vs. frequency as a function

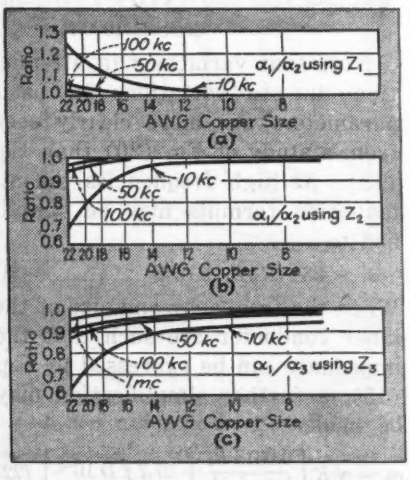


FIG. 10—Relative accuracies of attenuation factor as calculated from various approximations

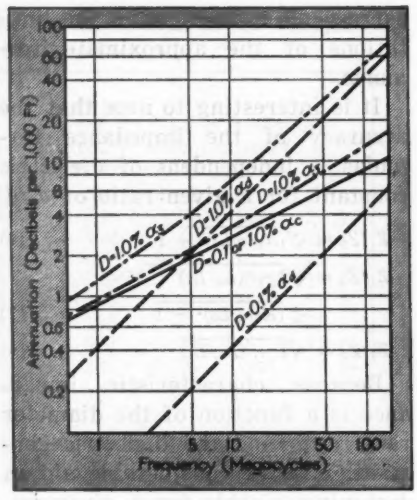


FIG. 11—Comparison of the effect of dissipation factor on attenuation, and the relative importance of copper and dielectric attenuation

of their individual variables. Copper attenuation is calculated for the condition that $\alpha_c = 4.34R_0/Z_0$ and dielectric attenuation for $\alpha_d = 27.7fD\sqrt{K}\ 10^{-6}$. For values other than those plotted in this graph, attenuations may be obtained by applying proper correction factors; that is, $\alpha_d = 0.042$ db/1000 ft at 10 megacycles when $K = 2.3$ and $D = 1$ percent. When $K = 2.4$ and $D = 1$ percent at 10 megacycles the dielectric loss $\alpha_d = 0.042\sqrt{2.4/2.3} = 0.0429$ db/1000 ft. Although these curves apply only to the frequency range in which the formula for α_0 may be used, the information obtained from them is useful in obtaining an approximation of the general design of a coaxial cable for any attenuation.

Phase-Shift Constant

Phase-shift constant or wavelength constant may be expressed at any frequency as

$$\beta_0 = \sqrt{0.5\sqrt{[R_0^2 + (\omega L_0)^2]\,[G^2 + (\omega C)^2]} - 0.5\,(GR_0 - \omega^2 L_0 C)} \quad \text{radians/1000 ft} \qquad (23)$$

Similar to the attenuation, the form of this equation may be changed to

$$\beta_1 = \sqrt{0.5\omega C\,[\omega L_0\,(\sqrt{(R_0/\omega L_0)^2 + 1}\,\sqrt{D^2 + 1} + 1) - DR_0]} \quad \text{radians/1000 ft} \qquad (24)$$

At high frequencies this equation may be simplified to

$$\beta_2 \cong \omega\sqrt{L_0 C} \quad \text{radians/1000 ft} \qquad (25)$$

The limitation of this formula, as for attenuation, depends upon the relative magnitude of the parameters and the frequency. However, as a general guide based upon a ratio of $d_2/d_1 = 3.55$, a solid-center conductor, a copper tube concentric conductor, and a dielectric having a dielectric constant of 2.3 and a dissipation factor of 1 percent, Eq. (25) may be used at frequencies as low as 50 kilocycles when the center conductor is at least No. 18 AWG.

The operating engineer is often interested in wavelength (λ) and velocity of propagation along the coaxial cable (V). These terms are a function of β_0 and may be determined from

$$\lambda = 2000\pi/\beta_0 \text{ feet} \qquad (26)$$

$$V = 1000\omega/\beta_0 \text{ feet/second} \qquad (27)$$

Velocity along the cable expressed in ratio to velocity in free space (V_0) is

$$V/V_0 = 1.016\,(\omega/\beta_0)\ 10^{-6} \qquad (28)$$

With the exact formulas available for checking accuracy, the approximate equations and the curves presented herein can reliably be used to determine basic cable parameters and from them the working parameters. Thus the cable-design engineer can study variations produced by cable dimensions and components, and the circuit engineer can interpret these factors in terms of cable performance.

Bibliography

(1) Whinnery, J. R., Skin Effect Formulas, ELECTRONICS, p. 44, Feb. 1942.
(2) Race and Larrick, High-Frequency Coaxial-Line Calculations, *Trans. A. I. E. E.*, p. 526, July 1942.
(3) Woodruff, L. F., "Principles of Electric Power Transmission."
(4) Bureau of Standards Circular No. 74.

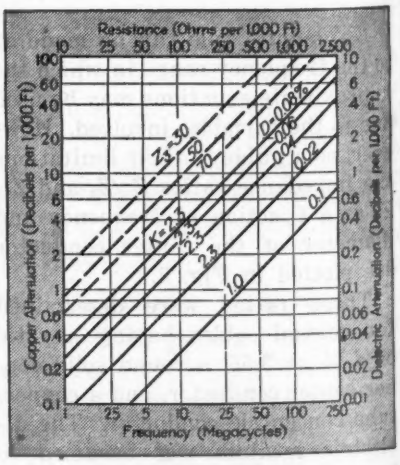


FIG. 12—Illustrative copper and dielectric attenuations, showing the manner in which they can be expected to vary

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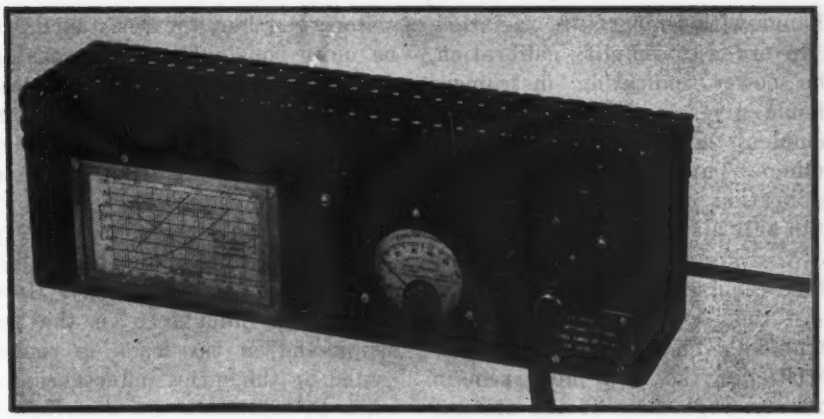


Dummy antenna for testing v-h-f transmitters

V-H-F DUMMY ANTENNA

Distributed reactances of a physical resistor are compensated, giving a pure resistance that simulates the antenna load of transmitters. A built-in thermo-galvanometer indicating power dissipated in the load facilitates tuning and coupling adjustments

THE PROBLEM of providing a dummy load with suitable characteristics for testing u-h-f and v-h-f transmitters has probably received the attention of many engineers, particularly in connection with production testing.

Development work and production testing require that the transmitter be operated into a load having an impedance which exactly represents that for which it is designed. This is particularly important where plate tuning and antenna coupling controls must be precalibrated at the factory. In this case a reactive load will usually cause plate circuit resonance to occur at a different point on the tuning control from that with the correct load, and also the degree of physical coupling to the output circuit will generally be different.

It is impractical, of course, for the manufacturer to use the actual load into which the transmitter will operate since this is usually a radiating system. Many radio factories are located near areas of important military or aircraft communication networks and radiation of any kind may cause serious interference. Development work and production testing, then, must be done with a compact load which does not radiate.

Requirements of Dummy Load

Rarely will the transmitter be designed for operation on only a single frequency, and as a result the dummy load will usually be called upon to operate over a range of frequencies. It must therefore have wide-band characteristics, or it must be easily adjustable for operation at any frequency within the desired range. This requires that the input impedance remains constant and essentially resistive over the operating frequency band.

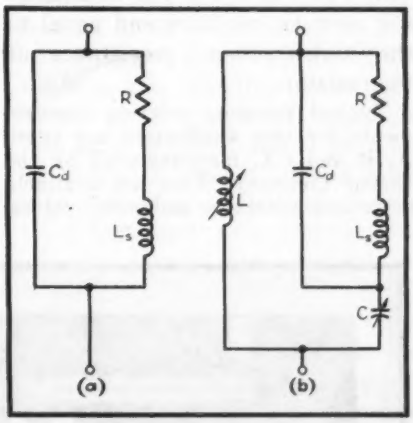


FIG. 1—(a) Distributed capacitance and inductance of a resistor at high frequencies can be represented by lumped constants. (b) To counteract these reactances, an external inductor *L* and capacitor *C* can be added to the resistor

Since the primary function of the transmitter is to deliver a given amount of power, the ideal dummy load should instantly give a reasonably accurate indication of the power delivered to it. There should be no time lag between the application and indication of the power, and fluctuations of short duration should register on the power indicator. This requirement eliminates calorimetric types of power meters. The power indicator should preferably operate at any value of power below the rated maximum so that loads do not have to be changed when measuring power levels at maximum and minimum transmitter output coupling. Thus incandescent power elements wherein pyrometers or phototubes are used to measure power can not be used because of their great impedance

change with temperature variation.

In order to simplify calibration, the power indicating instrument should give an indication proportional to the v-h-f load current or voltage. This will permit complete calibration for any power input with only a single calibration point. A thermocouple ammeter meets these requirements more closely at v-h-f than does any other type instrument. The impedance characteristic of the load must remain constant regardless of the amount of power delivered to it in order that transmitters of different power ratings may be tested with the same load, and so that quick checks may be made of the decoupling characteristics of the transmitter output circuit.

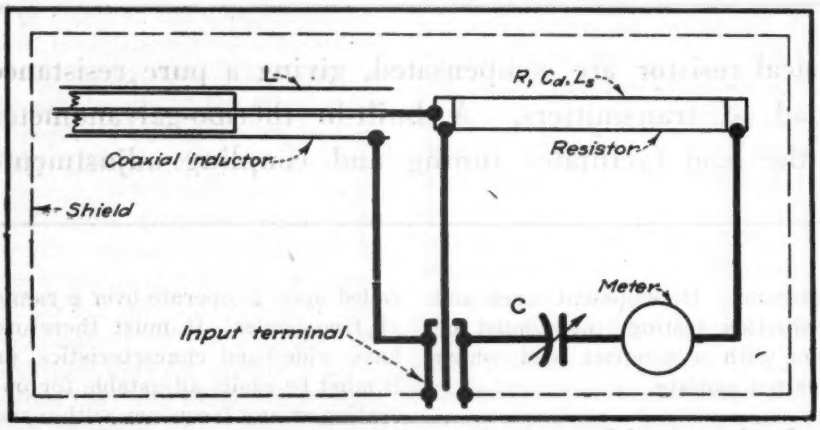


FIG. 2—Diagrammatic electrical circuit of artificial unbalanced load for v-h-f

Lastly, the power indicator must be sufficiently stable to maintain its calibration over long periods of time. This requires a dissipating element of rugged construction which can stand the mechanical abuse to which such an instrument is usually subjected. In addition, calibration should not be affected by changes in ambient temperature or by heat generated from power dissipated in the load resistor.

Distributed Reactance

Design centers around the dissipative element of the dummy load. A resistor becomes a complicated reactive and resistive network at very high frequencies and so cannot be used without modification. Inherently the carbon or composition resistor is perhaps most suited to u-h-f and v-h-f use since the reactive components can be kept small by careful design of the resistor. Further, the resistance can be quite constant with increasing frequency since skin effect is less pronounced in materials of high resistivity. Skin effect can be further reduced by molding the resistor in the form of a thin tube.

The composition resistor at very high frequencies may be represented as shown in Fig. 1(a). Here distributed inductance in the resistor and in the leads is represented by the series inductance L_s, while C_d represents the distributed shunt capacitance. If a resistor is chosen having the desired resistance value at low frequencies, the reactances appearing at high frequencies may be canceled by forming a series resonant circuit with an external capacitor and the distributed inductance, and a parallel resonant circuit with an external inductor and the distributed capacitance. This circuit arrangement is shown in Fig. 1(b). The impedance will now be resistive and equal to the high-frequency resistance of the resistor.

Typical resistors meeting requirements for this application are types A, B and CX, manufactured by the Globar Company. They are available in various resistance and power values. Type A has an essentially zero resistance-temperature coefficient, while types B and CX have slightly negative and slightly positive coefficients respectively.

Reactive Compensation

Series inductive reactance in a resistor of this type and its connecting leads is approximately 40 ohms at 100 Mc and may easily be resonated with a capacitance of approximately 40 $\mu\mu$f.

Shunt capacitance is extremely small and must be resonated with an inductance having a very high Q if the resistive component of the network is to remain unaltered. An ordinary coil of wire would be unsatisfactory for this purpose; however, a shorted section of coaxial transmission line, slightly less than a quarter-wavelength long, makes an excellent high-Q inductor and can be made readily adjustable.

The shunt inductance used to resonate the resistor was made from a piece of $\frac{3}{8}$-inch brass tubing. A No. 12 copper wire supported on ceramic beads formed the inner conductor. The outer tube was cut approximately in half and folded back on itself to conserve space. The shorting rod was made from $\frac{1}{16}$-inch brass tubing plugged at one end and drilled axially through the plug to accommodate the No. 12 wire. A small piece of phosphor bronze formed into a finger insured contact between the wire and the shorting rod. No beads were used on the adjustable section.

Figure 2 is a schematic diagram of the final load with the coaxial inductor and shunt ammeter. The unit was designed for operation over a frequency range of 105 to 135 Mc, but the values of external capacitance and shunt inductance may be varied so that the load operates at frequencies up to ap-

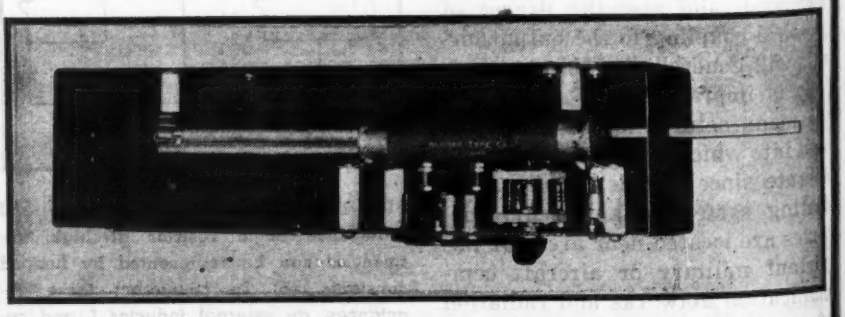


FIG. 3—Arrangement and proximity of parts is important in the v-h-f load

proximately 300 Mc. Above this the series reactance would be so large that it would be difficult to obtain a finite external capacitor small enough to give resonance. The high-frequency limit might be extended somewhat by replacing the capacitor with a shorted section of transmission line slightly longer than a quarter wavelength.

Built-in Wattmeter

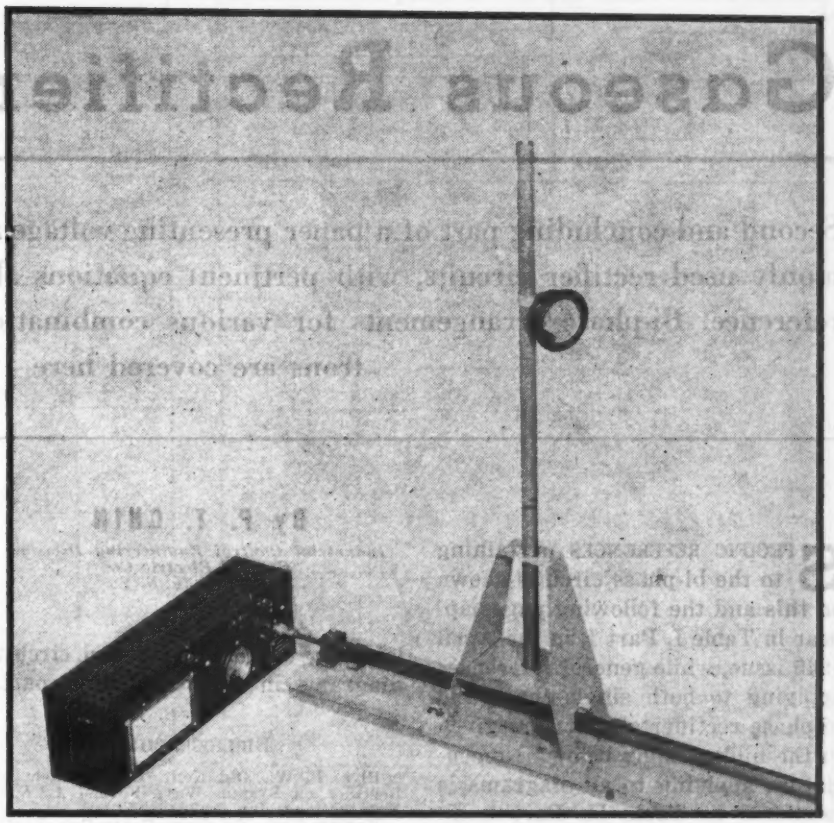
The load presents an essentially nonreactive impedance of 70 ohms to an unbalanced coaxial line and uses the Globar type of CX 70-ohm, 50-watt carbon resistor. All connecting leads between resistor, capacitor, and ground are made with wide copper straps. The terminals of the thermo-galvanometer used to measure power are connected directly across the section of the strap that joins the low-potential end of the resistor and the series capacitor, thus keeping the meter near ground to avoid effects of stray capacitance.

Arrangement of components, particularly the thermocouple ammeter and connecting leads, is important. It can be seen in detail in Fig. 3.

The wattmeter for the artificial load has a full-scale range of 115 ma. The width of the strap between its terminals was adjusted to give a half-scale deflection at 50 watts input. Being a current-squared thermocouple meter with the scale divided into 100 equal parts, the calibration in watts is linear. The useful lower limit of this load is 2 watts. Although the resistor is rated at only 50 watts the load can be used for short periods up to the full-scale reading of 100 watts. A slight adjustment of the shunt across the meter would allow full-scale readings on power inputs as low as 1 or 2 watts. No change in standing wave ratio was noticed at any power input. A model now under construction and using a removable shunt will have a full-scale range of either 10 or 100 watts.

Calibration

Input impedance was measured and the calibration of C, L, and I was done with a section of slotted coaxial transmission line. An infinite-impedance probe voltmeter



Slotted transmission line and high-impedance coaxial voltmeter used to calibrate the v-h-f dummy load

was made from a shorted section of coaxial transmission line one-quarter wavelength long, mounted in a trolley to ride in the slot. A sensitive thermo-galvanometer was shunted across a small section of the probe near the shorted end. The shorting bar was adjustable so that the probe could be resonated at any frequency in the range.

The slotted line used for measurement had a characteristic impedance of 66 ohms, while the load was designed for 70 ohms. Theoretically the standing wave ratio under these conditions would be 1.06 to 1. With L and C adjusted for optimum conditions the measured standing wave ratios were 1.06, 1.05, and 1.02 to 1 at frequencies of 130, 119, and 108 Mc respectively.

The wattmeter was calibrated by connecting to the slotted line an incandescent lamp-type load which had been calibrated at 60 cps. The maximum and minimum indications of the probe voltmeter were then recorded for a given power input. The power transmitted through a transmission line at high frequencies is $P = V_{max} V_{min}/Z_0$. If $V_{max}/V_{min} = A$, these two equations may be solved simultaneously, yielding $V_{max} = \sqrt{APZ_0}$. In this manner it was possible to calibrate the probe meter in terms of absolute voltage. The new load was then connected to the line and the power calculated from the new values of maximum and minimum probe voltage. It was necessary to calibrate at only one power level because of the linear voltage scale.

Considerable variation in power readings was expected with change in frequency; however, they were found to be remarkably constant varying over a range of 105 to 130 Mc only ± 3 percent from the calibration at 119 Mc. To allow for extreme accuracy, a multiplication factor was determined for these three frequencies and a curve plotted to cover the band.

Wide latitude in design is possible in power-handling capability, impedance, and frequency range by judiciously applying the principles outlined above. If care is taken to insure absolute symmetry from each input terminal, a balanced-input load arrangement can be built along these same general principles.

Gaseous Rectifier Circuits

Second and concluding part of a paper presenting voltage and current wave forms of commonly used rectifier circuits, with pertinent equations alongside curves for convenient reference. Bi-phase arrangements for various combinations of phanotrons and thyratrons are covered here

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SPECIFIC REFERENCES pertaining to the bi-phase circuits shown on this and the following pages appear in Table I, Part I, in the April 1945 issue, while general references applying to both single-phase and bi-phase rectifier circuits are given in the bibliography below. Nomenclature applying to all diagrams is tabulated in Table II, Part I, although in most cases the significance of each letter symbol in the equations can be deduced from the labelling on the curves and circuit diagrams in this concluding part.

BIBLIOGRAPHY

Blye, P. W., and Kent, H. E., Effect of Rectifier on System Wave Forms, *A.I.E.E. Transactions*, Jan. 1934, p. 54.

Herskind, C. C., Grid Controlled Rectifiers and Inverters, *A.I.E.E. Transactions*, June 1934, p. 927.

Stebbins, F. O., and Frick, C. W., Output Wave Shape of Controlled Rectifier, *A.I.E.E. Transactions*, Sept. 1934, p. 1259.

Journeaux, P., Voltage Control of Vapor Rectifiers, *A.I.E.E. Transactions*, June 1934, p. 976.

Stout, M. B., Analysis of Rectifier Filter Circuits, *A.I.E.E. Transactions*, Sept. 1935, p. 977.

Huss, P. O., An Analysis of Copper-Oxide Rectifier Circuits, *A.I.E.E. Transactions*, Mar. 1937.

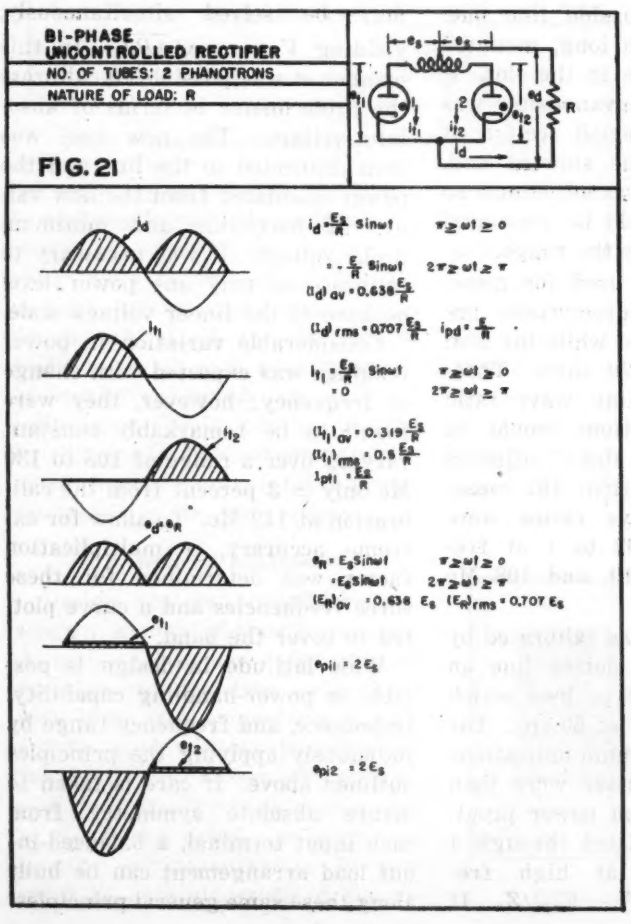
Herskind, C. C., Rectifier Circuit Duty, *A.I.E.E. Technical Paper* (44-41), 1943.

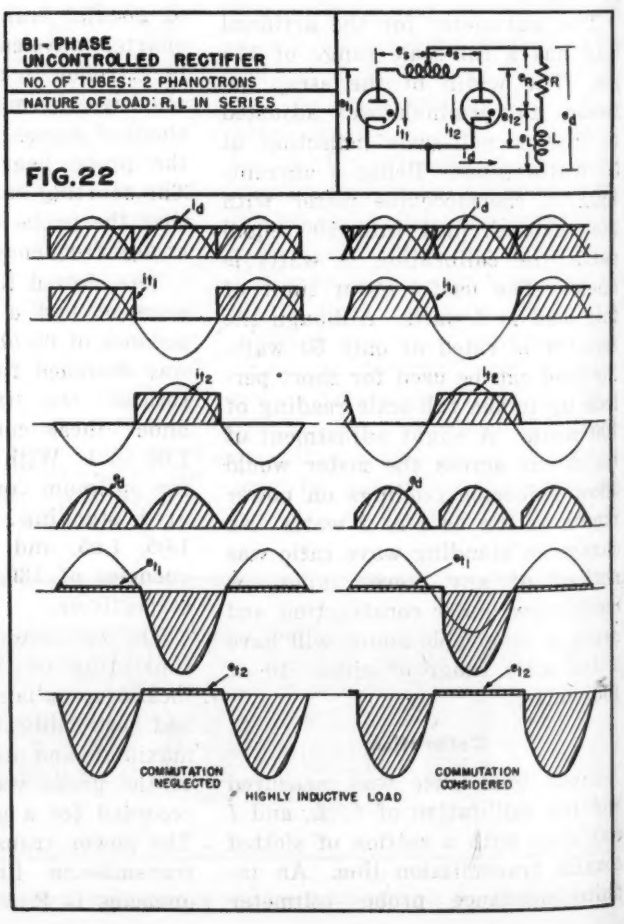
Panofsky, W. K. H., and Robinson, C. F., Graphical Solution of Rectifier Circuits, ELECTRONICS, Apr. 1941, p. 42-44.

Waidelich, D. L., Voltage Multiplier Circuits, ELECTRONICS, May 1941, p. 28-29.

Waidelich, D. L., and Gleason, C. H., The Half-Wave Voltage-Doubling Rectifier Circuit, *Proc. I.R.E.*, Dec. 1942, p. 535-541.

Durand, S. R., and Keller, O., Grid Control of Radio Rectifiers, *Proc. I.R.E.*, 25, 1937, p. 570-582.


BI-PHASE
UNCONTROLLED RECTIFIER
NO. OF TUBES: 2 PHANOTRONS
NATURE OF LOAD: R
FIG. 21
R
$i_d = \frac{E_s}{R} \sin\omega t \quad \pi \geq \omega t \geq 0$
$= -\frac{E_s}{R} \sin\omega t \quad 2\pi \geq \omega t \geq \pi$
$(i_d)_{av} = 0.636 \frac{E_s}{R}$
$(i_d)_{rms} = 0.707 \frac{E_s}{R} \quad i_{pd} = \frac{E_s}{R}$
$i_{t1} = \frac{E_s}{R} \sin\omega t \quad \pi \geq \omega t \geq 0$
$= 0 \quad 2\pi \geq \omega t \geq \pi$
$(i_{t1})_{av} = 0.319 \frac{E_s}{R}$
$(i_{t1})_{rms} = 0.5 \frac{E_s}{R}$
$i_{pt1} = \frac{E_s}{R}$
$e_R = E_s \sin\omega t \quad \pi \geq \omega t \geq 0$
$= E_s \sin\omega t \quad 2\pi \geq \omega t \geq \pi$
$(E_R)_{av} = 0.636 \; E_s \quad (E_R)_{rms} = 0.707 \; E_s$
$e_{pi1} = 2E_s$
$e_{pi2} = 2E_s$

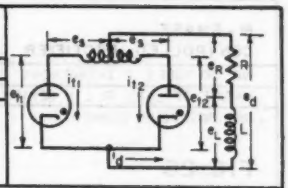


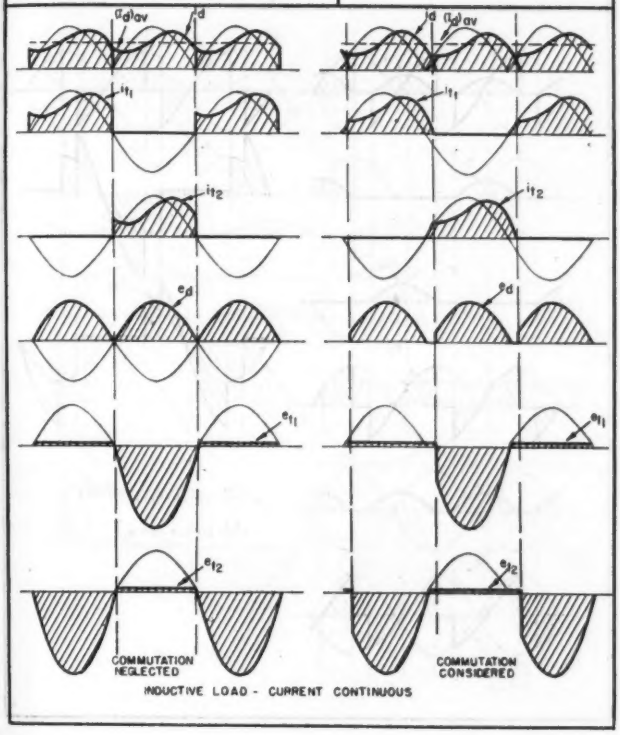
BI-PHASE UNCONTROLLED RECTIFIER

NO. OF TUBES: 2 PHANOTRONS

NATURE OF LOAD: R, L IN SERIES

FIG. 23





INDUCTIVE LOAD - CURRENT CONTINUOUS

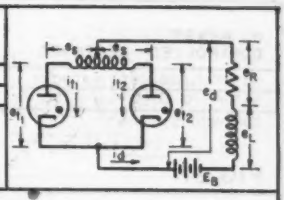
BI-PHASE UNCONTROLLED RECTIFIER

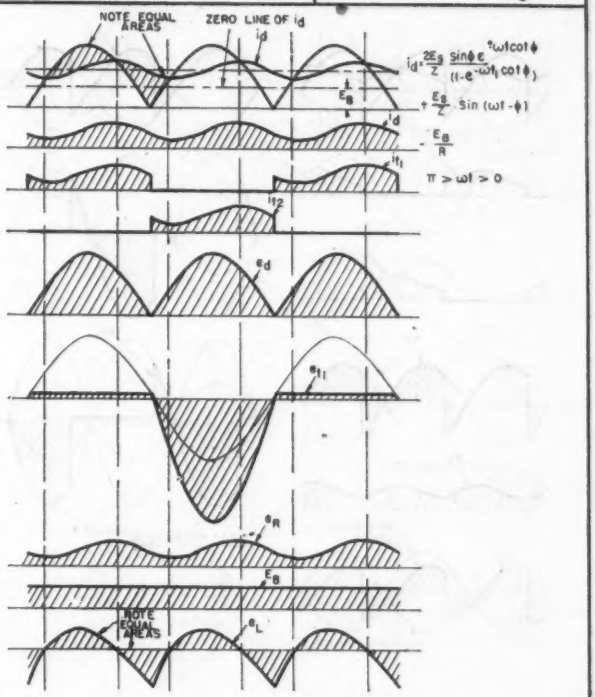
NO. OF TUBES: 2 PHANOTRONS

NATURE OF LOAD: R, L, E_B IN SERIES

CONTINUOUS CURRENT

FIG. 24




NOTE EQUAL AREAS
ZERO LINE OF i_d
$i_d = \frac{2E_s}{Z} \frac{\sin\phi\, e^{\omega t \cot\phi}}{(1-e^{-\omega t_1 \cot\phi})}$
$+ \frac{E_s}{Z} \sin(\omega t - \phi)$
$- \frac{E_B}{R}$
$\pi > \omega t > 0$
NOTE EQUAL AREAS

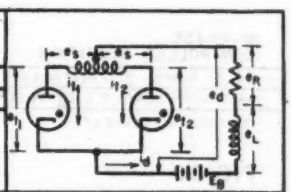
BI-PHASE UNCONTROLLED RECTIFIER

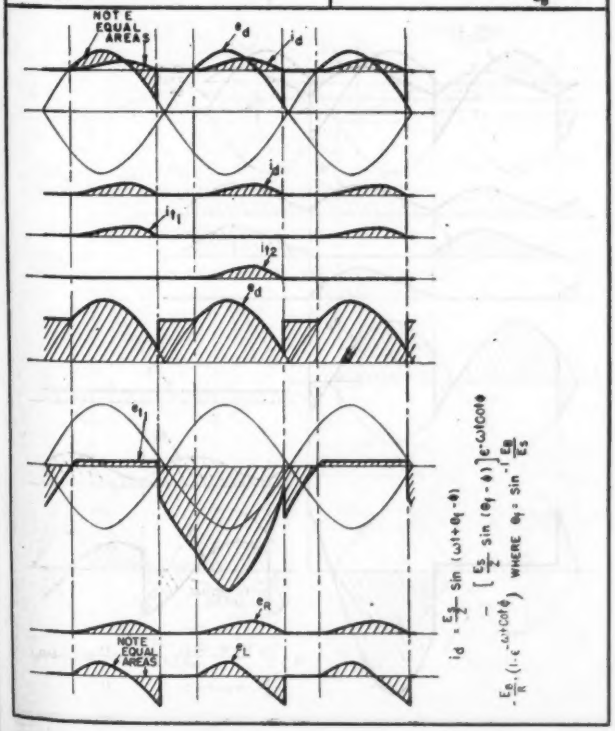
NO. OF TUBES: 2 PHANOTRONS

NATURE OF LOAD: R, L, E_B IN SERIES

DISCONTINUOUS CURRENT

FIG. 25



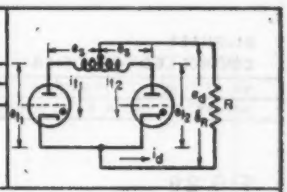

NOTE EQUAL AREAS
NOTE EQUAL AREAS
$i_d = \frac{E_s}{Z} \sin(\omega t + \theta_1 - \phi) - \left[\frac{E_s}{Z} \sin(\theta_1 - \phi)\right] e^{-\omega t \cot\phi} - \frac{E_B}{R}(1 - e^{-\omega t \cot\phi})$ WHERE $\theta_1 = \sin^{-1}\frac{E_B}{E_s}$

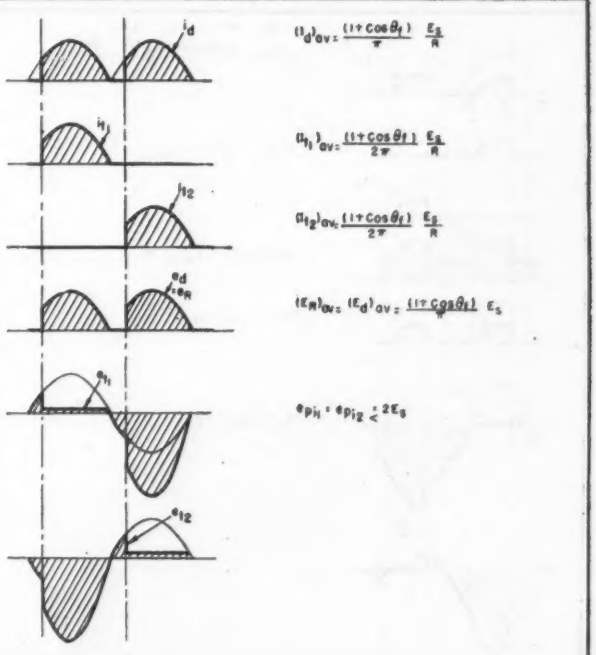
BI-PHASE CONTROLLED RECTIFIER

NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R

FIG. 26




$(i_d)_{av} = \frac{(1+\cos\theta_1)}{\pi} \frac{E_s}{R}$
$(i_{t_1})_{av} = \frac{(1+\cos\theta_1)}{2\pi} \frac{E_s}{R}$
$(i_{t_2})_{av} = \frac{(1+\cos\theta_1)}{2\pi} \frac{E_s}{R}$
$(E_R)_{av} = (E_d)_{av} = \frac{(1+\cos\theta_1)}{\pi} E_s$
$e_{p_{t_1}} = e_{p_{t_2}} = 2E_s$

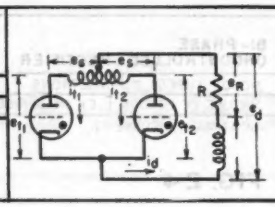
BI-PHASE CONTROLLED RECTIFIER

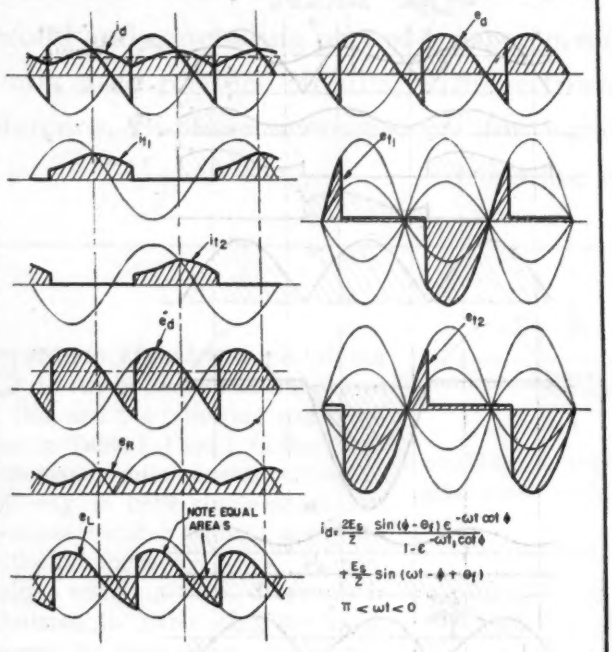
NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R, L IN SERIES

CONTINUOUS CURRENT

FIG. 27





$$i_d = \frac{2E_s}{Z}\,\frac{\sin(\phi-\theta_f)\,\epsilon^{-\omega t\cot\phi}}{1-\epsilon^{-\omega t_1\cot\phi}} + \frac{E_s}{2}\sin(\omega t-\phi+\theta_f)$$

$$\pi < \omega t < 0$$

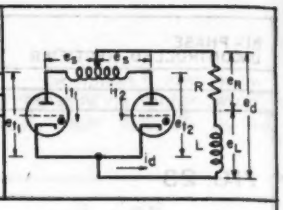
BI-PHASE CONTROLLED RECTIFIER

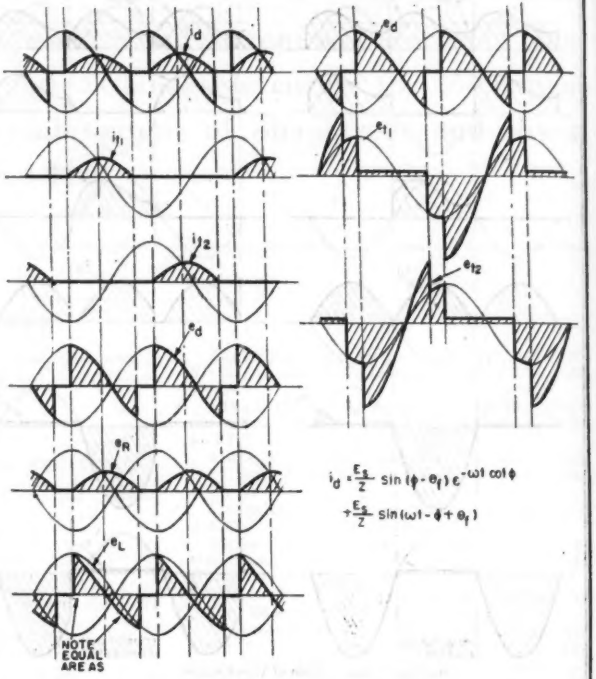
NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R, L IN SERIES

DISCONTINUOUS CURRENT

FIG. 28





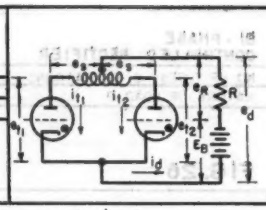
$$i_d = \frac{E_s}{Z}\sin(\phi-\theta_f)\,\epsilon^{-\omega t\cot\phi} + \frac{E_s}{2}\sin(\omega t-\phi+\theta_f)$$

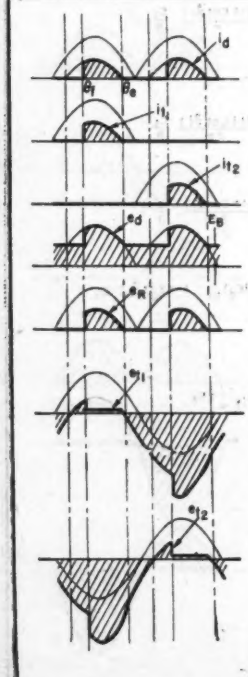
BI-PHASE CONTROLLED RECTIFIER

NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R, E_B IN SERIES

FIG. 29





$$\theta_e = 180° - \sin^{-1} E_B/E_s$$

$$(I_d)_{av} = \frac{E_s\cos\theta_e + E_B\left(\beta_f - \frac{\pi}{2}\right)}{\pi R}$$

$$(I_{t_1})_{av} = \frac{(I_d)_{av}}{2} = (I_{t_2})_{av}$$

$$(E_d)_{av} = E_B + (I_d)_{av}\,R$$

$$(E_R)_{av} = (I_d)_{av}\,R$$

$$e_{p_{i_1}} = e_{p_{i_2}} = 2E_s$$

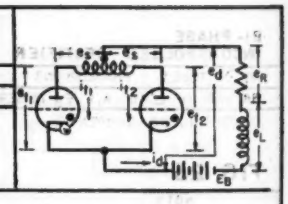
BI-PHASE CONTROLLED RECTIFIER

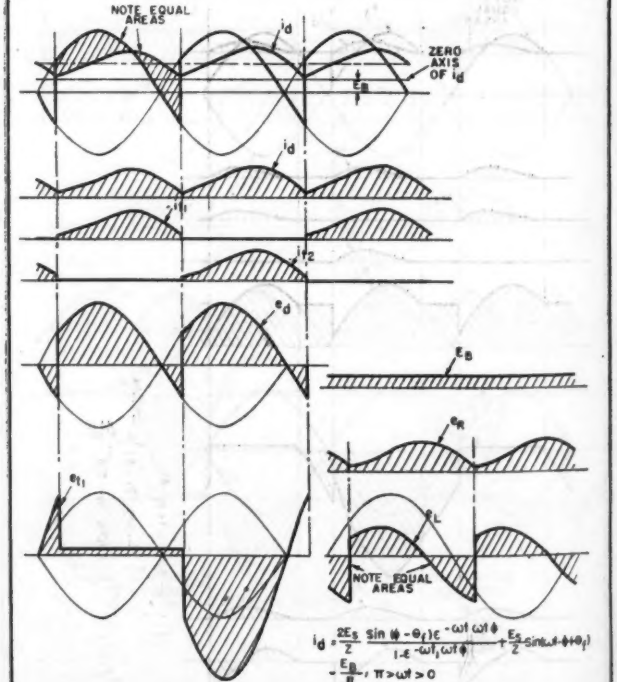
NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R, L, E_B IN SERIES

CONTINUOUS CURRENT

FIG. 30





$$i_d = \frac{2E_s}{Z}\,\frac{\sin\phi-\theta_f)\,\epsilon^{-\omega t\cot\phi}}{1-\epsilon^{-\omega t_1\cot\phi}} + \frac{E_s}{2}\sin(\omega t-\phi+\theta_f) - \frac{E_B}{R}, \quad \pi > \omega t > 0$$

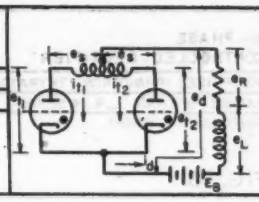
BI-PHASE CONTROLLED RECTIFIER

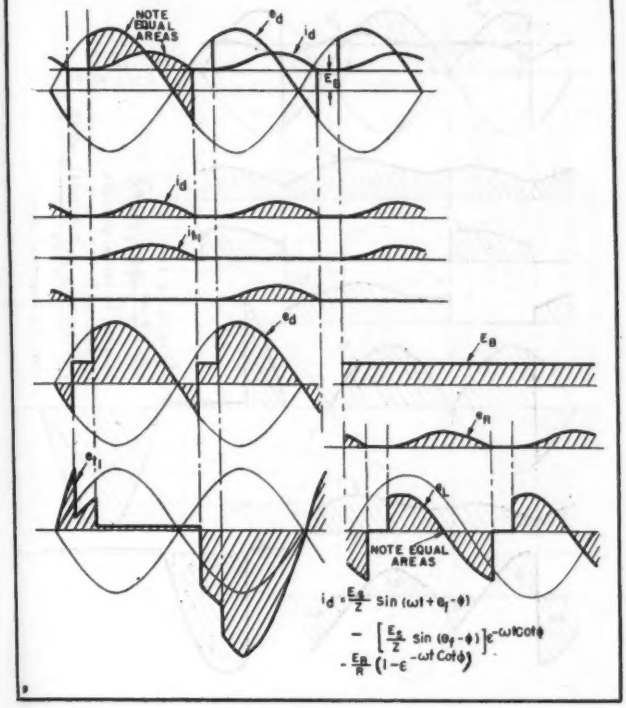
NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R, L, E_B IN SERIES

DISCONTINUOUS CURRENT

FIG. 31





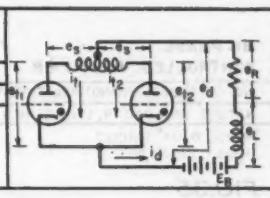
BI-PHASE CONTROLLED RECTIFIER

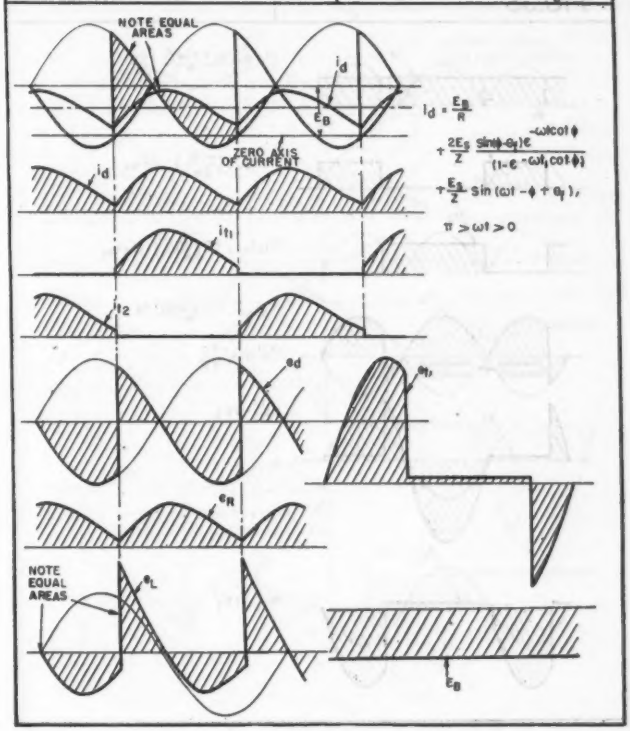
NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R, L, E_B IN SERIES

INVERSION (CONTINUOUS CURRENT)

FIG. 32





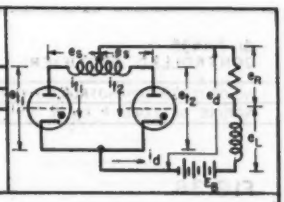
BI-PHASE CONTROLLED RECTIFIER

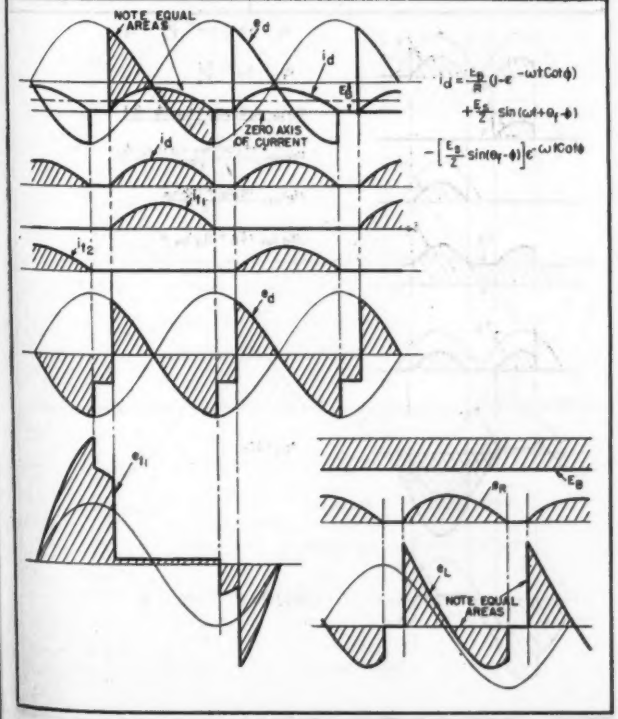
NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R, L, E_B IN SERIES

INVERSION (DISCONTINUOUS CURRENT)

FIG. 33



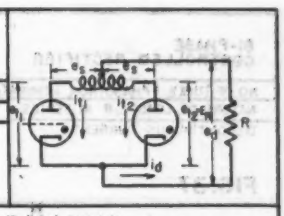


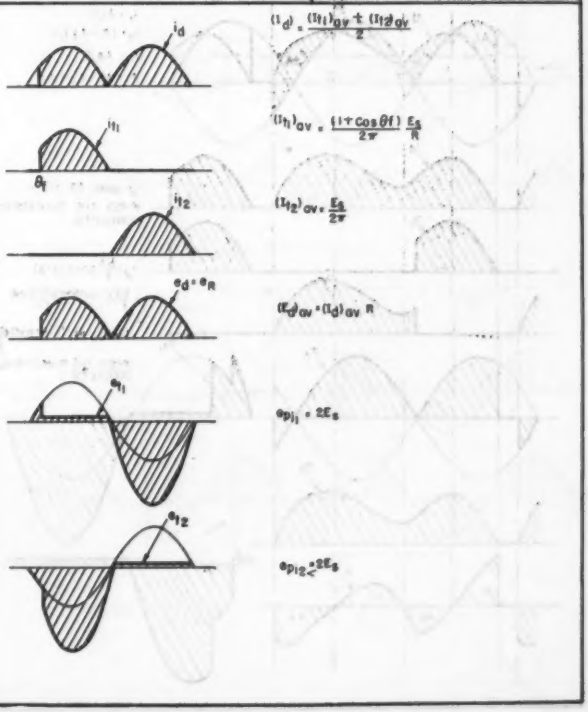
BI-PHASE CONTROLLED RECTIFIER

NO. OF TUBES: 1 PHANOTRON, 1 THYRATRON

NATURE OF LOAD: R

FIG. 34





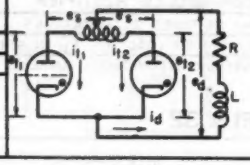
BI-PHASE CONTROLLED RECTIFIER

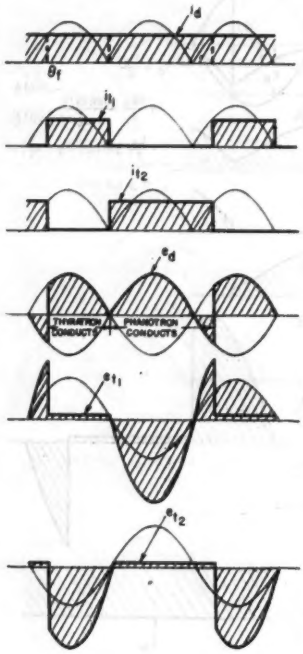
NO. OF TUBES: I PHANOTRON, I THYRATRON

NATURE OF LOAD: R, L IN SERIES

"HORSE & OX" CIRCUIT (HIGHLY INDUCTIVE)

FIG. 35





$$(I_d)_{av} = \frac{(1+\cos\theta_f)}{\pi}\frac{E_s}{R}$$

$$(I_{t_1})_{av} = \left(\frac{\pi-\theta_f}{2\pi}\right)(I_d)_{av}$$

$$(I_{t_2})_{av} = \left(\frac{\pi+\theta_f}{2\pi}\right)(I_d)_{av}$$

$$(E_d)_{av} = \frac{(1+\cos\theta_f)}{\pi}E_s$$

$$(E_d)_{rms} = \frac{E_s}{\sqrt{2}}$$

$$e_{p_{i_1}} = 2E_s$$

$$e_{p_{i_2}} = 2E_s$$

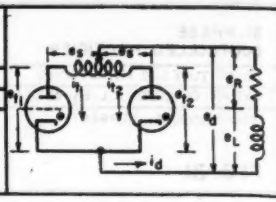
BI-PHASE CONTROLLED RECTIFIER

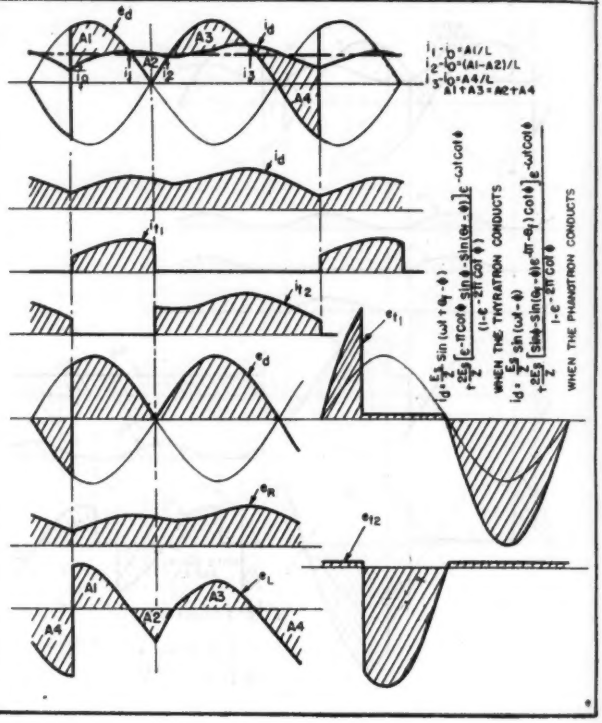
NO. OF TUBES: I PHANOTRON, I THYRATRON

NATURE OF LOAD: L, R IN SERIES

CONTINUOUS CURRENT

FIG. 36





$i_1 = b = A1/L$

$i_2 = (a-b) = (A1-A2)/L$

$i_3 = a = A4/L$

$A1+A3 = A2+A4$

$$i_d = \frac{E_s}{Z}\sin(\omega t+\theta_f-\phi) + \frac{2E_s}{Z}\left[\frac{e^{-\pi\cot\phi}\sin\phi\sin(\theta_f-\phi)}{(1-e^{-2\pi\cot\phi})}\right]e^{-\omega t\cot\phi}$$

WHEN THE THYRATRON CONDUCTS

$$i_d = \frac{E_s}{Z}\sin(\omega t-\phi) + \frac{2E_s}{Z}\left[\sinh\frac{-\sin(\theta_f-\phi)}{\sin\phi}e^{(\pi-\theta_f)\cot\phi}\right]e^{-\omega t\cot\phi}$$

WHEN THE PHANOTRON CONDUCTS

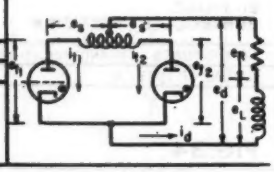
BI-PHASE CONTROLLED RECTIFIER

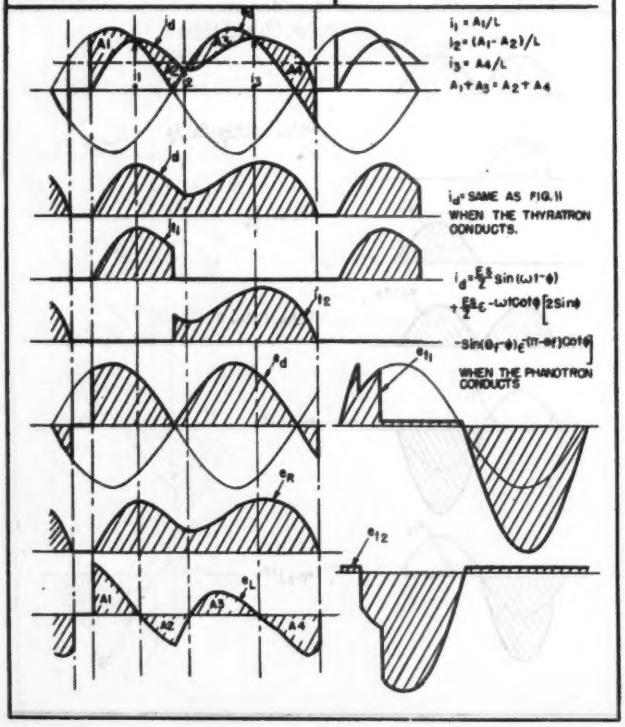
NO. OF TUBES: I PHANOTRON, I THYRATRON

NATURE OF LOAD: L, R IN SERIES

DISCONTINUOUS CURRENT

FIG. 37





$i_1 = A_1/L$

$i_2 = (A_1-A_2)/L$

$i_3 = A_4/L$

$A_1+A_3 = A_2+A_4$

i_d = SAME AS FIG. 11 WHEN THE THYRATRON CONDUCTS.

$$i_d = \frac{E_s}{Z}\sin(\omega t-\phi) + \frac{E_s}{Z}e^{-\omega t\cot\phi}\left[2\sin\phi\right.$$
$$\left.-\sin(\theta_f-\phi)e^{(\pi-\theta_f)\cot\phi}\right]$$

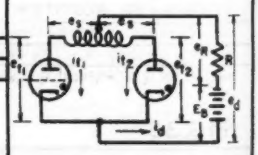
WHEN THE PHANOTRON CONDUCTS

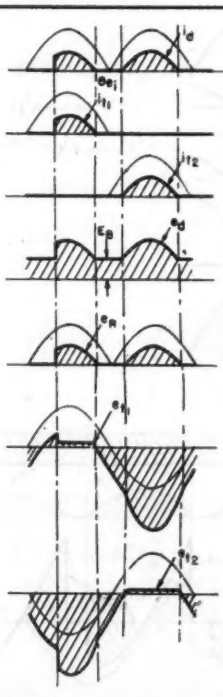
BI-PHASE CONTROLLED RECTIFIER

NO. OF TUBES: I PHANOTRON, I THYRATRON

NATURE OF LOAD: R, E_B IN SERIES

FIG. 38





$$\theta_{e_1} = 180° - \sin^{-1}\frac{E_B}{E_s} = \theta_{e_2}$$

$$\theta_{f_2} = \sin^{-1}\frac{E_B}{E_s}$$

$$(I_{t_1})_{av} = \frac{E_s\cos\theta_{t_1} + E_B(\theta_f-\frac{\pi}{2})}{\pi R}$$

$$(I_{t_2})_{av} = \frac{2E_s\cos\theta_{f_2} - E_B(\theta_{e_2}-\theta_{f_2})}{2\pi R}$$

$$(I_d)_{av} = \frac{(I_{t_1})_{av}+(I_{t_2})_{av}}{2}$$

$$(E_d)_{av} = E_B + (I_d)_{av}R$$

$$e_{p_{i_1}} = 2E_s$$

$$e_{p_{i_2}} = 2E_s$$

BI-PHASE CONTROLLED RECTIFIER

NO. OF TUBES: I PHANOTRON, I THYRATRON

NATURE OF LOAD: L, R, E_B IN SERIES

CONTINUOUS CURRENT

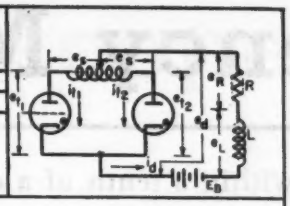
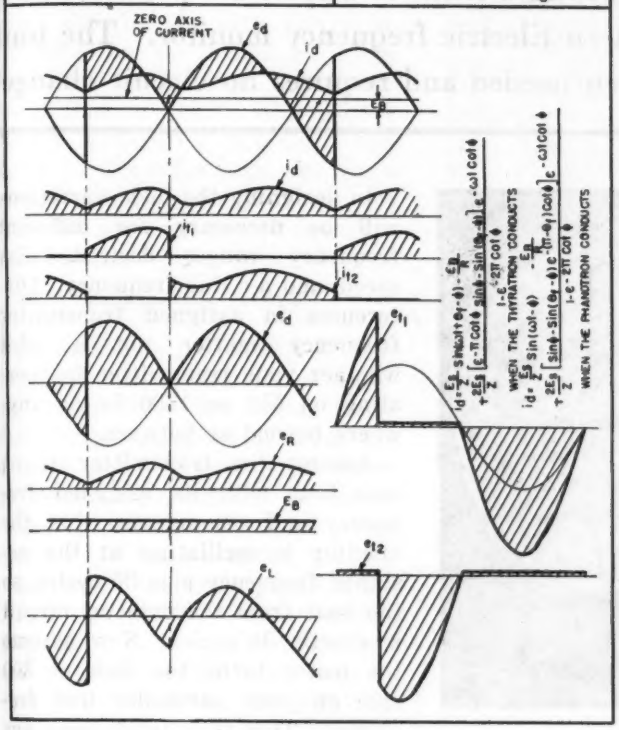


FIG. 39



BI-PHASE CONTROLLED RECTIFIER

NO. OF TUBES: I PHANOTRON, I THYRATRON

NATURE OF LOAD: L, R, E_B IN SERIES

DISCONTINUOUS CURRENT

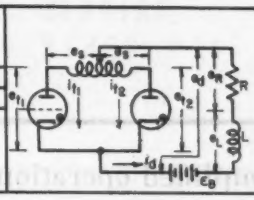
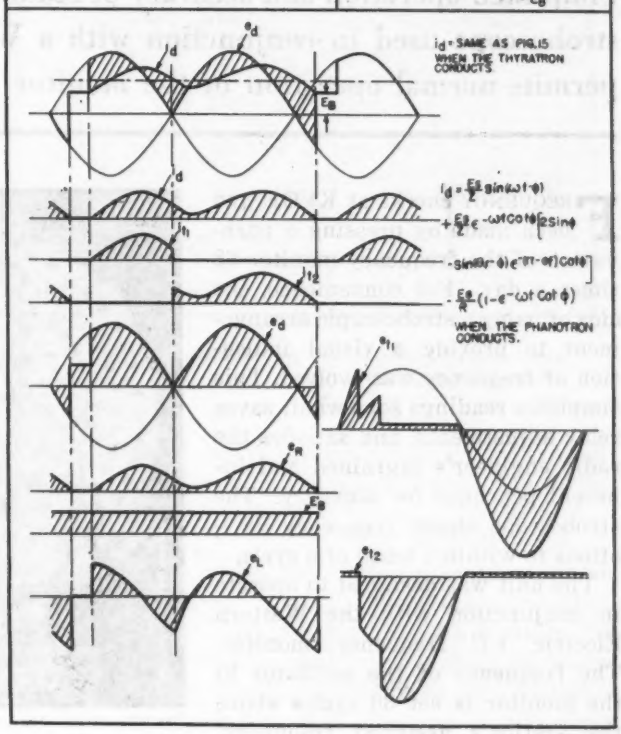


FIG. 40



INVERSE PARALLEL CIRCUIT PHASE CONTROLLED

NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: R

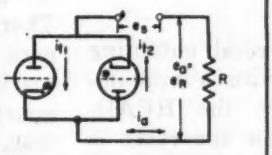
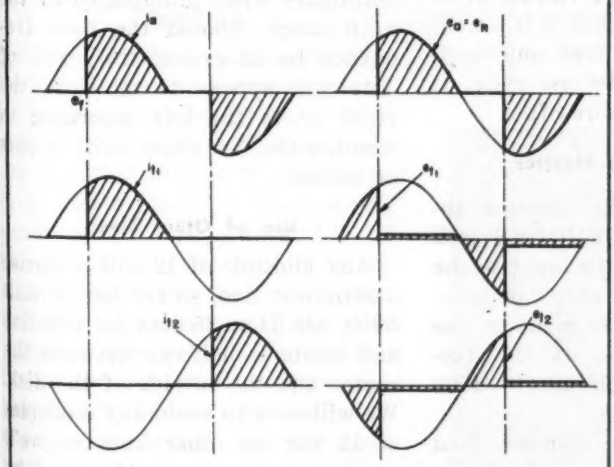


FIG. 41



$i_a = \frac{E_s}{R}\sin\omega t$ $\quad (0 \geq \omega t \geq \theta_f \quad 2\pi \geq \omega_1 \geq (\pi+\theta_f))$

$= 0$ $\quad (\theta_f \geq \omega t \geq 0 \quad (\pi+\theta_f) \geq \omega t \geq \pi)$

$(I_a)_{av} = 0$

$(I_a)_{rms} = \frac{E_s}{R}\left[\frac{1}{2\pi}(\pi-\theta_f) + \frac{\sin^2\theta_f}{4}\right]^{\frac{1}{2}}$

$e_{p_i} \leq E_s$

$e_R = i_a R \quad (E_R)_{av} = 0 \quad (E_R)_{rms} = (I_a)_{rms} R$

INVERSE PARALLEL CIRCUIT PHASE CONTROLLED

NO. OF TUBES: 2 THYRATRONS

NATURE OF LOAD: L, R IN SERIES

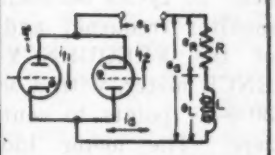
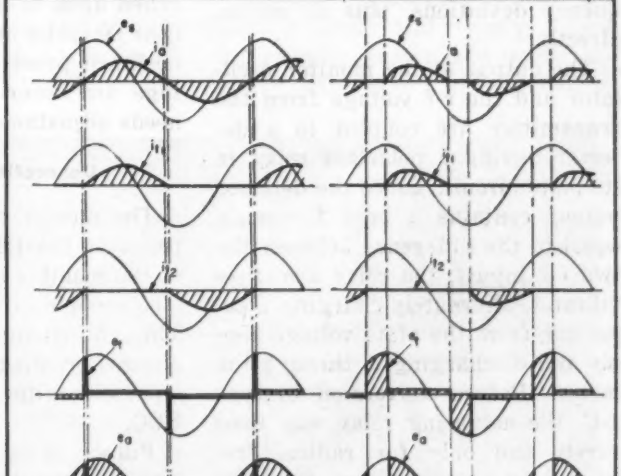


FIG. 42


MAX. CURRENT
$\theta_f = \phi$
(FIRING ANGLE = P.F. ANGLE OF LOAD)
CURRENT REDUCED
$\theta_f > \phi$
(SEE SINGLE PHASE CONTROLLED RECTIFIER. NATURE OF LOAD: R, L IN SERIES)

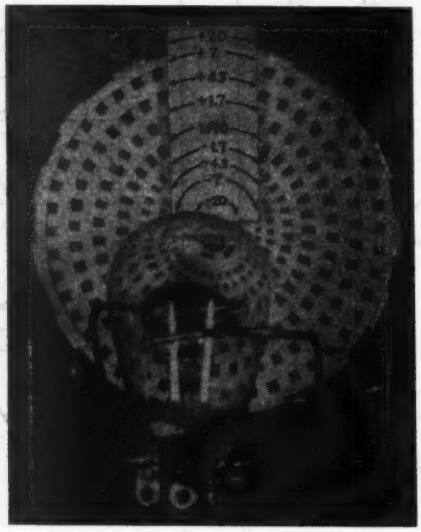
Frequency Monitor S

Simplified operation and accuracy of reading within a tenth of a cycle are provided by a stroboscope used in conjunction with a Western Electric frequency monitor. The unit permits normal operation of the monitor when needed and requires no circuit change

FREQUENCY checks at KVOE had been made by pressing a push-button of the frequency monitor 68 times a day. For convenience, the idea of using a stroboscopic arrangement to provide a visual indication of frequency was evolved. This simplifies readings somewhat, saves relay adjustments, and satisfies the radio engineer's ingrained and inherent penchant for accuracy. The stroboscope shows frequency deviations to within a tenth of a cycle.

The unit was designed to operate in conjunction with the Western Electric 1-C frequency monitor. The frequency of the oscillator in the monitor is set 30 cycles above the station's assigned frequency. When the transmitter is on zero beat there is a difference of exactly 30 cycles between it and the monitor frequency and the needle of the FREQUENCY DIFFERENCE meter, with a scale reading 30-0-30, points to center scale or zero. The meter indicates frequency deviations, plus or minus, directly.

The output of the monitor oscillator and the r-f voltage from the transmitter are coupled to a detector having a polarized relay in its plate circuit. Since the detector output contains a beat frequency equal to the difference between the two r-f inputs, the relay armature vibrates, alternately charging a capacitor from the plate voltage supply and discharging it through the meter. Before conversion to type 1-C, the actuating relay was used rarely and only for radical frequency deviations of more than five cycles. The oscillator frequency of the old type 1-A was set at zero beat with the carrier frequency and operation was well within five cycles. Under this deviation, the FREQUENCY DIFFERENCE meter readings were not accurate and most operators will recall obtaining readings visually with a milliammeter plugged into the HEADPHONES jack. Now the relay is called upon to always vibrate at or near 30 cycles and while it is a well-designed precision item, and readings are accurate to one cycle, it needs adjustment more often.



Details of the completed disk which is illuminated by the neon bulb to provide the stroboscopic effect

Connection to Monitor

The output of the detector appears at the HEADPHONES jack of the monitor and the input to the stroboscopic circuit plugs in here. Thus, no changes are made in the circuit or operation of the frequency monitor itself approved by FCC.

Pulses from the monitor feed into the two-stage amplifier shown in the diagram. This in turn feeds a 2-watt neon lamp which illuminates a disk which is rotated by a synchronous motor. On the disk are dots or squares arranged in circles and spaced according to the frequency indications desired.

In designing the disk, variations will be necessary for different frequency ranges desired, disk speed, and a-c line frequency. Differences in assigned transmitter frequency matter not a whit whether your transmitter is operating on 550 or 1600 kc or anywhere beyond or between.

Assume the transmitter is on zero beat with its assigned frequency and assume also that the monitor is oscillating at the assigned frequency plus 30 cycles, so the beat from the detector circuit is exactly 30 cycles. Now assume the motor turns the disk at 300 rpm on your particular line frequency. This is 5 revolutions per second. The neon lamp is flashing 60 times per second since it flashes on each alternation of 30 cycles. Therefore there are 12 flashes for each revolution of the disk so if we mark 12 dots, spaced 30 degrees apart along a circular line on the disk, this circle of dots will appear stationary when illuminated by the neon lamp. Should the beat frequency be 32 cycles, the circle of dots will appear to move to the right or to the left according to whether the frequency shift is plus or minus.

Use of Other Lines

Any multiple of 12 will comprise a zero-beat line, so for better visibility use 24 or 36 dots for this line and locate it halfway between the center and the outside of the disk. We will have to avoid any multiples of 12 for the other lines or we'll run into harmonic troubles; so take an odd figure and add to or subtract it from our "primary standard" to construct the other frequency lines.

In the unit illustrated, it was decided to read frequency deviations of plus or minus 1.7 cycles, 4.3

Stroboscope

By WALLACE S. WIGGINS
and S. G. GUENTHER
KVOE, Santa Ana, California

cycles and in-between. We add 1.7 to 12 and use the sum (13.7) in multiples for the PLUS 1.7 cycle line. Subtract 1.7 from 12 and use the difference (10.3) in multiples for the MINUS 1.7 cycle line. And so on for the other lines—as many as you wish, although five or six lines are sufficient for all practical purposes.

Construction of Disk

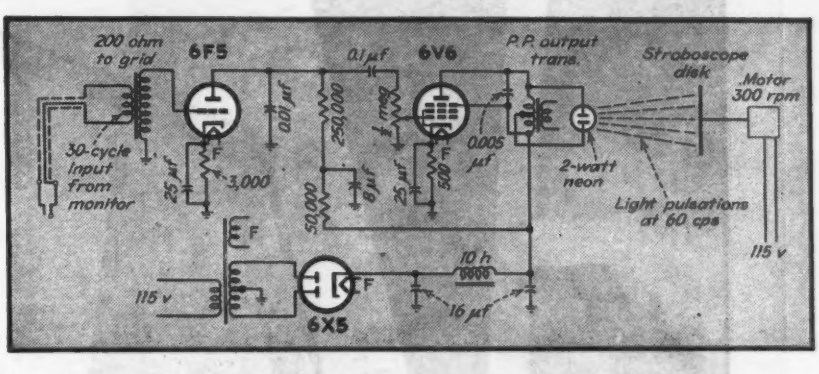
To make the disk, draw it first in pencil on a large piece of drawing paper about five or six times the actual size needed. Plot the number of marks or dots per circle by degrees or fractions thereof with a protractor. Then ink them in with dull black drawing ink. To one side on the same paper, draw an indicating scale that will designate the various values of the lines and make this to the same scale as the disk. Then photograph the drawings, reduce them to the size required, and mount them.

The disk can be mounted on the motor shaft with any suitable tin or cardboard backing. The scale is placed over and clear from it, supported either from the front or back. Mount a viewing lens in the can cover at a convenient angle.

Operation

Take a reading on the monitor itself, in the usual manner (by pressing the button). Let's say it reads plus 2 cycles. Now squint at the rotating disk and you'll discover the PLUS 1.7 line moving slowly to the left. The PLUS 4.3 line is moving quite rapidly to the right; therefore the actual frequency indication is a little more than 1.7 cycles but considerably less than 4.3 cycles. With a little practice, you'll be able to read frequencies so closely it will make your skin creep.

For example: If the carrier frequency or center line is moving to the right (clockwise) at the same speed that the MINUS 1.7 line is moving counterclockwise, the obvious difference is half of 1.7 or minus 0.85 cycles. The same method



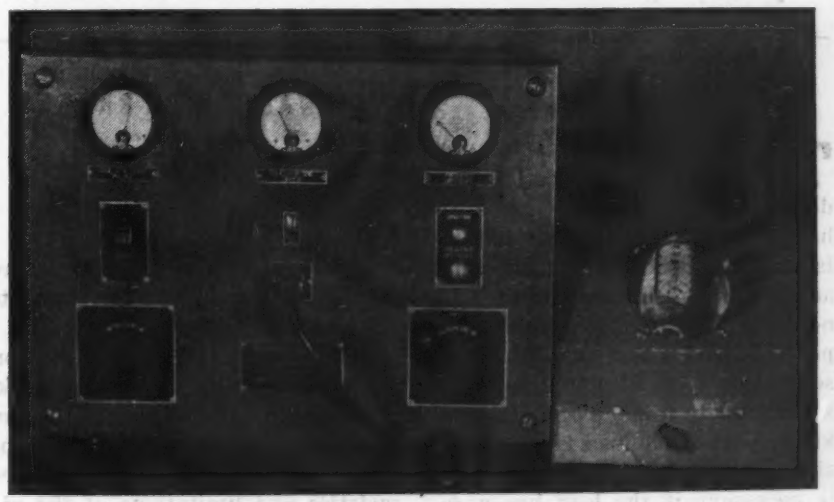
Pulses from the frequency monitor are amplified by the electronic circuit shown above to light the neon bulb on each alternation of the 30-cps signal

of interpolation is applied to the other lines to compute other fractional differences and you will be able to tell, at a glance, just how many cycles and tenths of a cycle the deviation is.

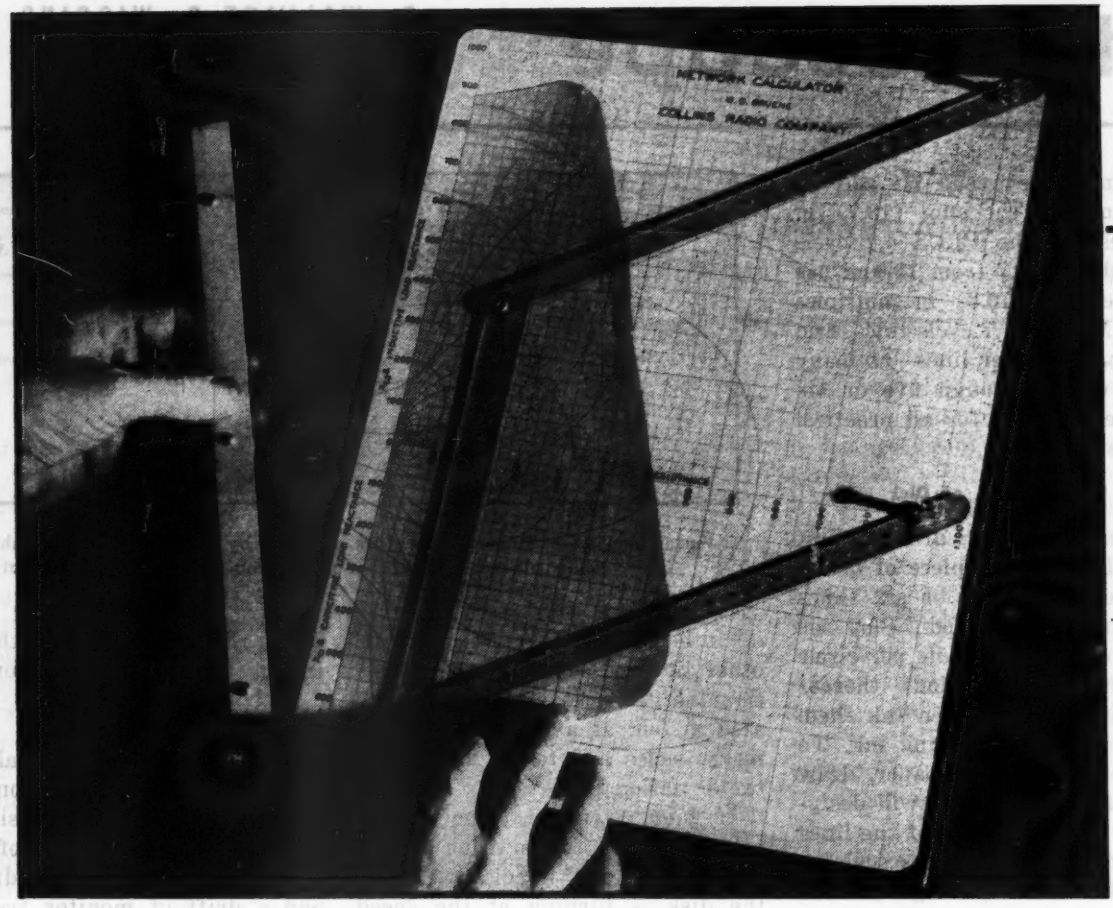
If your power frequency is dependable, if the computation used in drawing the disk is correct, and if the disk is turning at the speed computed, the indication of the stroboscope must be correct. Check it with the monitor. Change the frequency of the monitor by pushing the DIRECTION button which, on the Western Electric monitor, introduces an artificial frequency deviation. The speed of rotation of the various lines will change accordingly and you should be able to stop any one of them (within a range of 10 cycles), each of which should agree rather closely with the reading on the frequency-monitor meter.

Other Factors

A check with an external standard might be somewhat confusing. This is explained by a possible and often simultaneous drift of transmitter frequency in one direction and a drift of monitor frequency in the other. The monitoring service will tell you the actual frequency of the transmitter only, while your own monitor may have drifted enough in the opposite direction to compensate for the transmitter drift, thereby indicating no drift at all or zero beat. The stroboscope is coordinated with the monitor alone and simply makes the reading easier and more accurate with respect to the monitor.



Frequency monitor and stroboscope set up for operation. A phone plug is the only connection between the two units



This calculator not only gives the solution to pi-network design problems, but also indicates the operating range, effects of tuning and load presented to the tube

Pi-Network Calculator

Graphical method of calculating reactances for a pi network that will match a given complex load to a given tube plate circuit. Changes in tube loading that are produced by varying the elements of the network can be studied directly from the calculator

By **WARREN B. BRUENE**

Design Engineer
Collins Radio Company
Cedar Rapids, Iowa

THE PI-NETWORK CALCULATOR described in this article was developed for obtaining rapid solutions of pi-network problems. It is also useful for studying the characteristics and limitations of a pi-network when used to couple an r-f power amplifier to a load. Only one setting of this calculator is necessary to determine all of the unknowns when the load is a pure resistance, and only one more setting is necessary if the load has a reactive component. The graphical solution, which forms the basis for this calculator, gives a clear picture of the relationship of the elements of the pi-network.

After indicating the function and requirements of a pi-network, the graphical analysis will be made, which will include a brief description of the calculator. The characteristics and limitations of the pi-network and the relationship of the elements will be discussed.

The pi-network, Fig. 1(a), which consists of two capacitors and an inductor, will provide a tank circuit of the desired Q and also match the tube impedance into a wide range of load impedances. The proper values of the reactances of the pi-network and their practical limits will be discussed.

Circuit Design Considerations

One of the first considerations to be made in designing a tank circuit for an r-f power amplifier is the circulating current or Q of the

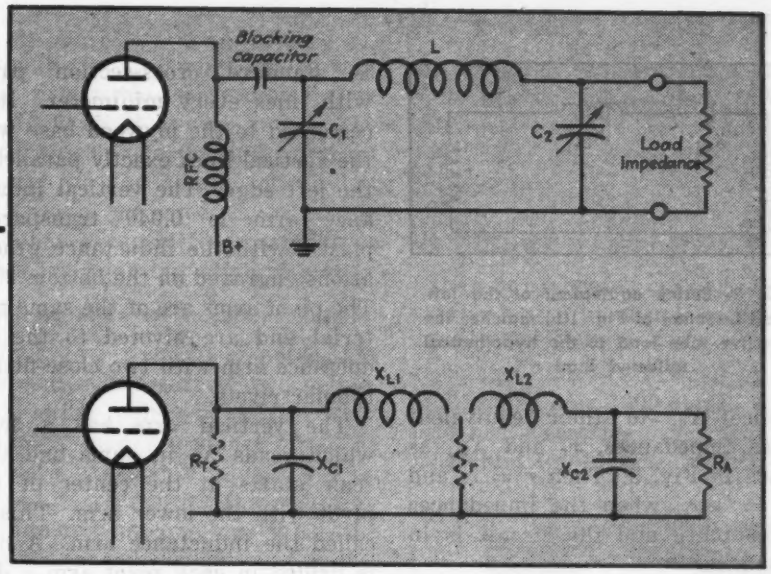


FIG. 1—Upper circuit (a) shows the pi-network used to couple the tube plate circuit to the load. The lower circuit (b) shows this physical circuit divided for graphical analysis into two L-sections

tank circuit. Too low a value of Q will result in poor harmonic attenuation and lowered tube efficiency, while high values of Q if carried to extremes will result in lower tank-circuit efficiency and sideband clipping on high-fidelity transmission.[1] For most communication purposes a Q of 10 is a good choice, but usually values from 8 to 20 are satisfactory.

In a common parallel resonant tank circuit, inductively coupled to a load, the tank circuit Q can be considered as the ratio of the reactance of the coil to the load resistance reflected into it. This is also equal to the ratio of the r-f effective load resistance of the tube, R_T, to the reactance of the tuning capacitor X_{C1}.

$$Q = \frac{X_L}{r} = \frac{R_T}{X_{C1}}$$

In this discussion the latter ratio will be considered to be the tank circuit Q of the pi-network. The value of R_T can be determined from calculations of the operating conditions of the tube, or more simply, by estimating the r-f plate voltage and the power output and then calculating R_T. For example, if the d-c plate voltage is 1000 volts, the r-f plate swing for class C operation may be estimated at 800 volts. If the power output is 160 watts, then

$$R_T = \frac{e^2_{peak}}{2P} = \frac{(800)^2}{2\,(160)} = 2000 \text{ ohms}$$

Development of Graphical Method

For analytical purposes, divide the pi-network into two L networks that match into a common imaginary resistance as shown in Fig. 1(b).

With R_T known, choose a value of X_{C1} that will give the desired Q and then determine X_{L1} and r. This is done graphically[2, 3] as shown in Fig. 2(a). This operation converts the parallel resistance R_T and re-

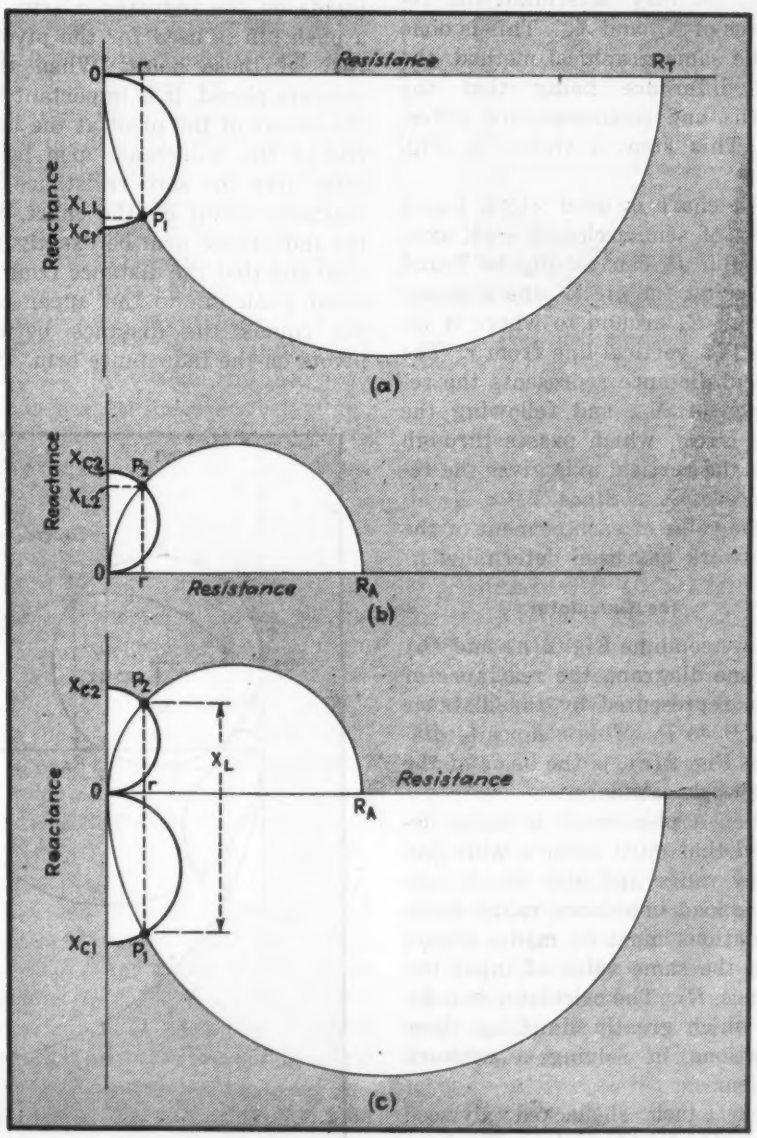


FIG. 2—Graphical methods are used (a) to convert the left-hand half of the circuit of Fig. 1(b) to the equivalent series circuit of Fig. 3, and (b) to obtain the values for the right-hand half of the circuit of Fig. 1(b). These two operations are combined at (c)

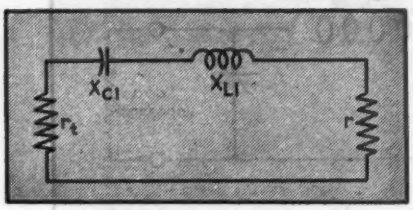


FIG. 3—Series equivalent of the left-hand L-section of Fig. 1(b) matches the effective tube load to the hypothetical reflected load r

actance X_{C1} to their equivalent series impedances, r_t and X_{c1}, as shown in Fig. 3. Then $r = r_t$ and $X_{L1} = -x_{c1}$ when the impedances are matched and the circuit is in resonance.

Knowing r and the load resistance, we may determine the reactance of X_{L2} and X_{C2}. This is done by the same graphical method, the only differance being that the knowns and unknowns are different. This step is shown in Fig. 2(b).

If a chart is used which has a family of semicircles on each axis, the point P_2 can readily be found by tracing the circle which passes through R_A around to where it intersects a vertical line from r. The vertical distance represents the reactance of X_{L2}, and following the other circle, which passes through P_2, to the vertical axis gives the reactance of X_{C2}. Since $X_L = X_{L1} + X_{L2}$ the value of each element of the pi-network has been determined.

The Calculator

If we combine Fig. 2(a) and (b) into one diagram, the reactance of X_L is represented by the distance from P_1 to P_2. This composite diagram, Fig. 2(c), is the basis of the pi-network calculator.

When a pi-network is being designed that must cover a wide frequency range and also match into a wide load impedance range many calculations must be made, always using the same value of input impedance, R_T. The calculator is a device which greatly simplifies these operations in solving a network problem.

The ¼-inch shellacked plywood base is 11½ by 14½ inches. The base chart on which the inductance and resistance circles are constructed is standard cross-section paper with lines every millimeter. It is cemented to the plywood base with the vertical lines exactly parallel to the left edge. The vertical inductance arm is 0.040 transparent plastic with the inductance graduations engraved on the bottom side. The pivot arms are of the same material and are pivoted to the inductance arm with two close-fitting tubular rivets.

The vertical arm has a scale which reads X_L in ohms and this scale starts at the center of the pivot with the lower arm. This is called the inductance arm. A hole is drilled in each pivot arm a distance of $R_T/2$ from the center of the pivots on the inductance arm, and a push pin is used for the pivot in each of these holes. When these pins are placed, it is important that the center of the pivot at the lower end of the inductance arm be exactly over the zero resistance and reactance point on the chart, that the inductance arm be exactly vertical and that the distance from the lower push pin to the upper push pin equals the distance between pivots on the inductance arm. Now when the inductance arm is moved, the lower end of the inductance scale will automatically follow the circle which passes through R_T.

The lower end of the inductance arm has two curved lines extending to the left from the pivot point. These curved lines were developed so that for two values of R_T they would cross the vertical axis of the chart at X_{C1}. The two values of R_T chosen for developing these curves were the maximum value accommodated by the calculator and one half of the maximum value. (If the value of R_T in a problem does not fall between these limits, all scales may be multiplied or divided by some factor so that it will.) These two lines are close together so it is easy to interpolate between them for setting X_{C1}. With this device, the circles shown in Fig. 2(a) are no longer needed for solving the first half of the network problem.

Manipulation of the Calculator

To use the calculator set the curve on the inductance arm at X_{C1}. Then follow the circle which passes through the load resistance

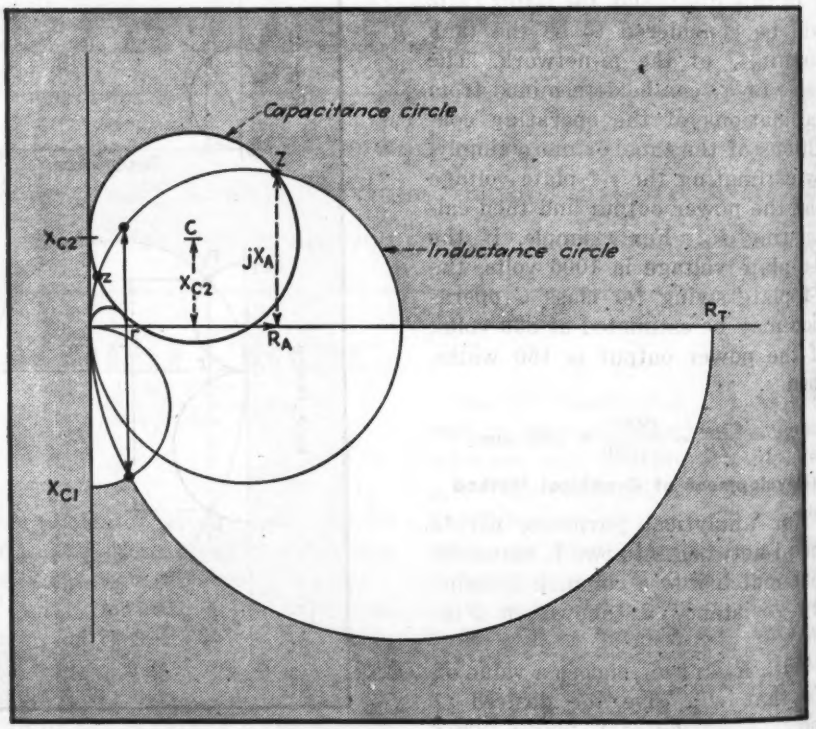


FIG. 4—Addition of a slide carrying circles tangent to the reactance axis permits making matching calculations for reactive loads

R_4 up and around to where it intersects the vertical scale on the inductance arm. Read the inductive reactance at this point, then follow the other circle over to the x axis and read X_{C_2}.

Up to this point the load has been considered as a pure resistance. If the load has a reactive component, it can be converted into equivalent parallel resistance and reactance. Solve the problem by matching into this equivalent parallel resistance and then correct X_{C_2} by the amount of the equivalent parallel load reactance. This can be quickly done by converting each reactance into positive or negative capacitance at some frequency by use of a reactance chart.[4] Add, if the load is inductive; subtract, if it is capacitive.

For example, if the load is 500 — $j500$, the equivalent parallel impedances are 1000 ohms resistance and 1000 ohms capacitive reactance. Assume that the network requires 200 ohms X_{C_2} to match into the 1000-ohm resistance. At 1 megacycle, 1000 ohms is 159 $\mu\mu$f and 200 ohms is 795 $\mu\mu$f. The actual capacitance of C_2 is then 795 $\mu\mu$f minus 159 $\mu\mu$f, or 636 $\mu\mu$f and its reactance X_{C_2} is 250 ohms.

Capacitance Calculations

Another simple method was developed which permits X_{C_2} to be read directly when the load impedance has a reactive component. It was found that the center of a circle, which passes through the load impedance point and is tangent to the x axis and tangent to a circle whose diameter is r, is a distance X_{C_2} above the zero reactance line.[5] This circle is shown in Fig. 4.

The capacitance slide has a family of circles which are all tangent at a common point, and is constructed so that it can be slide up and down with this common point of tangency always on the x axis. The circles are scribed on 0.010 transparent plastic sheet, and a guide is fastened to the sheet with screws.

To use this device, slide it up or down so that some circle or interpolation between circles passes through the load point and is tangent to a circle whose diameter is r. X_{C_2} is read at the line on the slide which is on the horizontal diameter of the family of circles. This works the same way when the load has a capacitive reactance as when it has an inductive reactance.

Interpretation of Calculator Results

In Fig. 4 it should be noted that the circles intersect at two points. This other point, z, is the other value of load impedance that the network will match into as well as Z and it represents the condition beyond critical coupling. When the load impedance is low and inductive, Z and z may be close together and the network can be tuned for either operating condition. It is easy to know when one is operating at point z because an increase in the loading capacitance, C_2, will increase the loading; whereas, when operating normally (at point Z) decreasing the capacitance of C_2 increases the load on the tube.

For practical purposes there are several factors which limit the range of load impedances that the pi-network will match into. The network will not match into load impedances in the area below the semi-circle whose diameter is r and extending down to negative infinity, as illustrated in Fig. 5. This area can be reduced by increasing the circuit Q as this decreases the value of r.

Another common practical restriction is caused by the minimum and maximum capacitance of capacitor C_2. At minimum capacitance the reactance X_{C_2} will be highest so that the load impedance must be inside a circle tangent at X_{C_2} and also tangent to the circle whose diameter is r. At maximum capacitance of C_2, X_{C_2} is at its minimum so the load impedance is restricted to an area outside of a circle tangent at X_{C_2} and to the circle whose diameter is r. This latter restriction exists only when the network is always adjusted to a point less than critical coupling.

The most important restriction is the maximum safe operating voltage for capacitor C_2. This capacitor has the same voltage across it as the load. For example, if the maximum safe voltage across C_2 is 2000 volts peak and the power output is 1000 watts, the maximum load resistance is

$$R = \frac{E^2}{2P} = \frac{(2000)^2}{2(1000)} = 2000 \text{ ohms}$$

for an unmodulated carrier. If the carrier is amplitude-modulated 100 percent, the above value of load resistance must be divided by two and is then only 1000 ohms. If the load has a reactive component, the maximum impedances, which have

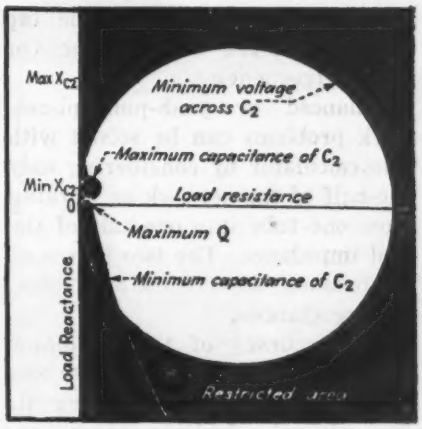


FIG. 5—Impedance transformations possible with a pi network limit the load that can be matched to within the area indicated by the calculator

the same load voltage, lie on the circle which passes through the maximum resistive load as determined above. It is seen that a load impedance of 500 + $j500$ will have the same voltage for a given power output as 1000 ohms pure resistance. The inductance circles on the calculator can thus be used as constant load-voltage circles.

In determining the above restrictions, it was assumed that the inductance could be adjusted to any necessary value. The maximum amount of inductance required is determined at the lowest frequency at which the network is to be used by using the desired amount of X_{C_1} and making a calculation on the amount of inductive reactance necessary to match to the highest load impedance to be encountered. For lower load impedances and higher frequencies, the coil can be tapped to secure lower inductance. In practice, a considerable fre-

quency range and load impedance range can be covered on a given tap position by just tuning the two capacitors. The limit to the frequency range which can be covered is determined by the maximum and minimum values of Q desired. For a given load, when the frequency is increased, the capacitances will decrease and so will the Q. When the minimum desired Q is reached, the coil is switched to the next lower tap, which is located so that the network will have the maximum desired value of Q when retuned. If the load impedance is lower (or higher), the same tap will be changed at a higher (or lower) frequency.

Balanced or push-pull pi-network problems can be solved with this calculator by considering only one-half of the network as working from one tube into one-half of the load impedance. The two halves of the balanced pi-network have identical reactances.

The accuracy of the calculator depends on its physical size and the precision used in making it. The original calculator was accurate to about 5 ohms when determining the reactances of the pi-network elements except that it becomes less accurate when r becomes very small (Q becomes high). In general, the results are as good or better that can be obtained using a slide rule. Because the number of operations to be performed on the calculator are few, chances for mathematical errors are greatly reduced when designing any type of pi-network.

A very interesting study of the relationship of the elements of the pi-network can be made with this calculator. There are three reactance elements in the pi-network plus the input resistance and the load impedance, any one of which may be varied to observe the effect on another.

Circuit Analysis

For one example, illustrated in Fig. 6, consider R_T, X_{C1}, and X_L fixed and observe the locus of load impedances that can be matched by varying only X_{C2}. Any load impedance which lies on the inductance circle, which passes through the value of X_L on the inductance arm, can be matched by varying only X_{C2}. As the load impedance point moves clockwise around this circle the reactance of X_{C2} increases (capacitance decreases).

When R_T, X_{C1}, and X_{C2} are fixed, the locus of load impedances, shown in Fig. 7, which can be matched by varying X_L, lies on the sliding capacitance circle which is tangent to the circle whose diameter is r. As the load impedance point moves clockwise around this capacitance circle, the reactance of X_L decreases.

Prediction of Tube Operation

A graphical picture of what happens when the pi-network, shown in Fig. 1, is tuned up is shown in Fig. 8(a). The load impedance, R_A is a fixed resistance and a value of X_L is chosen which will result in a satisfactory circuit Q when the network is tuned for proper loading of the tube and for resonance. The tube resistance R_T depends on the load placed upon the tube. When the tube is lightly loaded R_T will be high and when it is loaded heavier, R_T will be less. The adjustments of C_2 and C_1 serve to load the tube to the desired power input (or output) and to tune the circuit to resonance.

This graphical construction shows the relationship between X_{C2}, X_{C1} and load resistance on the tube. The one pivot arm must pivot on the center of the circle which passe through the load resistance. If X_{C2} is increased and X_{C1} is decreased to bring the network back

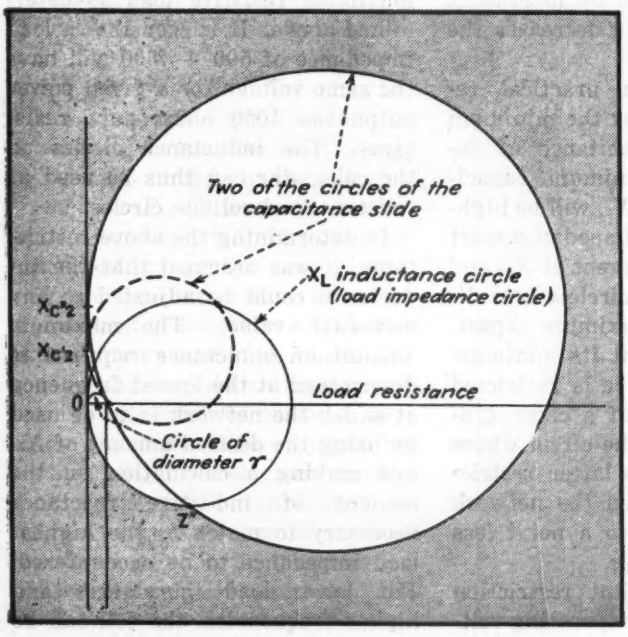


FIG. 6—Impedances that can be matched by varying X_{C2} are determined by settings of the capacitance slide

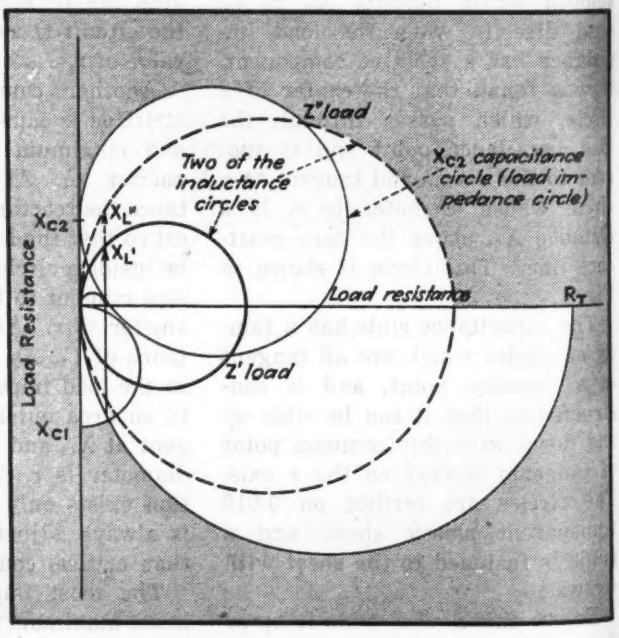


FIG. 7—Impedances that can be matched by varying X_L with all other parameters constant can be found

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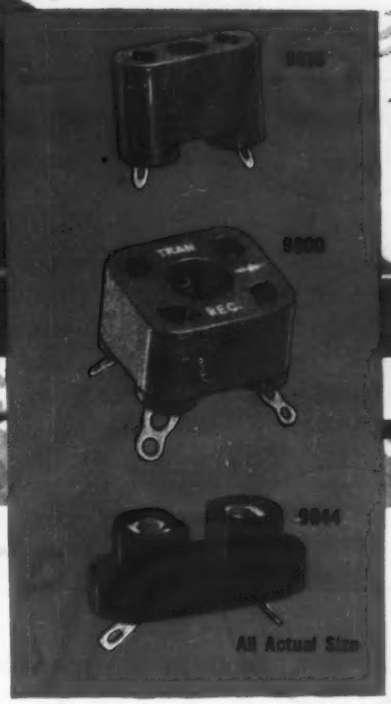

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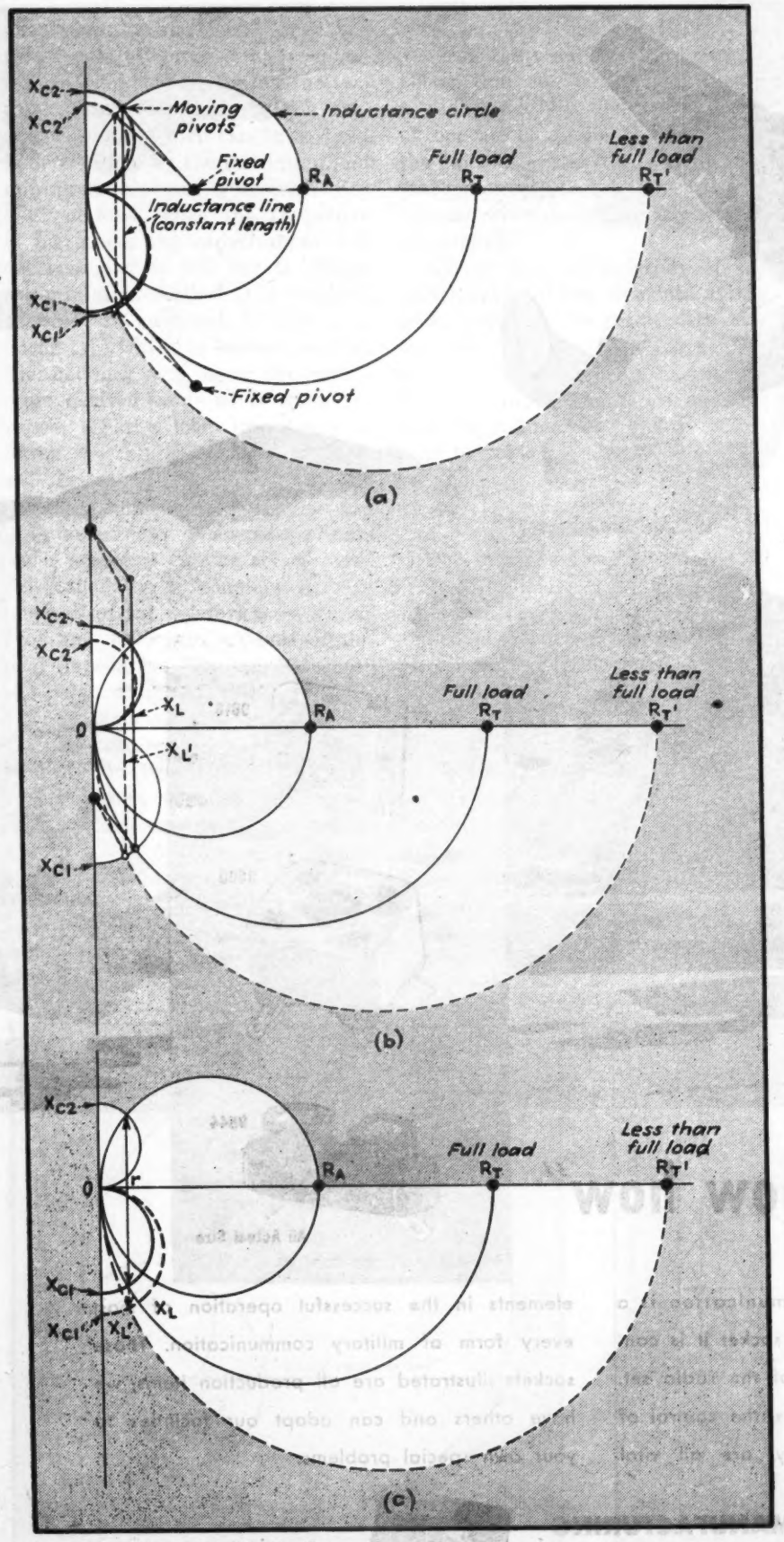

FIG. 8—(a) Effect on tube loading of varying the tuning capacitors is readily shown on the calculator. Other variables can be used such as (b) X_L and X_{C2} or (c) X_L and X_{C1} and the effect on the load that is reflected back to the tube can be studied

into resonance, then R_T is found to be less, which means that the tube is loaded more heavily.

This operation is just the opposite of what the calculator was intended to do, but it can be done easily if the fixed pivot on the lower pivot arm is located a distance equal to X_L exactly below the center of the inductance circle which passes through the load resistance, R_A.

Figure 8(b) shows the relationship when X_{C1} and R_A are fixed and tuning is accomplished by varying X_L and X_{C2}. The calculator can also be set to perform this calculation if it is desired.

If X_{C2} is fixed and X_{C1} and X_L are the variables, the construction is rather simple and is shown in Fig. 8(c).

Conclusions

In conclusion, it is suggested that a simple and inexpensive calculator can be made which is based on the construction shown in Fig. 2(c). A family of circles with their centers on the horizontal axis, and also the two families of semicircles with their centers on the vertical axis, are constructed on millimeter ruled paper as was used for the base chart for the calculator. A transparent centimeter scale can be used for the inductance scale. The end of the scale is placed on point P_1 with the scale placed in an exactly vertical position. The inductance can be read off on this scale at point P_2 using the same scale (ohms per centimeter) as used on the base chart.

This base chart is also useful for other purposes, as for calculating L-network reactances and converting series resistance and reactance to their equivalent parallel resistance and reactance.

References

(1) Newhouse, Arvid B., Power Amplifier Plate Tank Circuits, ELECTRONICS, 14, p. 32-35, Nov. 1941.
(2) Paine, Robert C., Geometric-Solutions for Resonant Impedance Transforming Networks, *Radio*, p. 36-37, 59, Oct. 1943.
(3) Toombs, R., Chart for Equivalent Series and Parallel Circuits, ELECTRONICS, 16, p. 109-110, Apr. 1943.
(4) Lorenzen, R., "A-C Calculation Charts," John F. Rider, Publisher, Inc., 1942.
(5) Smith, Phillip H., L-Type Impedance Transforming Circuits, ELECTRONICS, 15, p. 48-54, 125, Mar. 1942.

Building Tomorrows into Today's Products

IF George Washington could have owned a modern electric refrigerator, it might not be a museum piece today. Judging by performance tests of Mallory contacts for refrigerator motors, 194x's electric refrigerator could have cooled the drinks and preserved the food of George Washington and be capable of performing the same service for today's guests at Mt. Vernon.

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#1	1,556,000	85 years	Good
#2	2,134,000	171 years	Good
#3	3,075,000	168 years	Good
#4	3,230,000	177 years	Good
#5	3,277,000	180 years	Good

Mallory contacts are used on refrigerator motors to cut out the starting winding after full motor speed is obtained. Under adverse conditions, a refrigerator motor goes through fifty such operations in twenty-four hours. Speeding up the time interval to 512 operations per hour on five motors, running at 1750 R. P. M., it was demonstrated that Mallory contacts could operate perfectly for 85 to 180 years and *still be in good condition.* This again is indicative of the built-in quality of Mallory contacts which assures faultless service from standard contacts engineered to out-live the product for which they were designed.

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Photoelectric Gaging of Piston Rings

TO ELIMINATE the human element in production checking of piston rings and thus attain a very high degree of accuracy, a new electronic instrument automatically inspects the trueness of periphery and the width of gap of a specific size of piston ring. Inspection is much faster than present hand-checking methods and the production rate is determined by the speed at which the rings are presented to the gage. The inspection cycle per piece is less than five seconds.

Piston rings are inserted in a master ring and rotated under a light beam for electronic checking of true and width of gap

The piston ring to be checked is inserted inside a master ring of correct dimensional quality which is placed on the instrument table and rotated by a power-driven roller. The gaging functions are performed by scanning beams of light directed onto phototubes which energize electronic circuits to illuminate three signal lights.

As the ring revolves, one beam of light is projected on the periphery of the piston ring. A clearance between it and the master ring will result from any out-of-round condition of the piston ring, permitting part of the light beam to fall on the phototube. This actuates a red rejection signal should an excessive amount of light indicate that the piston ring is out-of-round beyond an acceptable point.

If the periphery is within tolerance limits, a green signal flashes on at the end of one complete revolution provided the width of gap is also within tolerance. The beam of light is interrupted by a mechanical shutter arrangement at the time the gap is passing this point.

Another beam of light scans the width of gap and actuates a yellow signal should the gap be undersize. A third beam of light energizes another circuit to illuminate the red rejection signal should the width of gap be oversize.

Master piston rings of known dimensional quality are used in adjusting the instrument for the desired tolerances. Made by The Sheffield Corporation, the instrument can be adapted to various nominal sizes, gaps of varying width, and also for variations on the allowable out-of-roundness of the periphery. Trueness of the periphery can be determined within a tolerance of 0.0001 inch.

Industrial X-Ray Installations in Ford Plant

OF ALL THE WAR PLANTS throughout the country, Ford Motor Company is a leading user of x-ray industrial equipment. Radiation at voltages from 5,000 to 1,000,000 covers the entire range of industrial radiography, from the study of very thin samples by microradiography to inspection of steel castings eight inches thick.

Castings passing through a Ford production x-ray department are segregated into groups according to the x-ray unit best adapted for their examination. Sorting tables, numbering machines, and record entries precede the transfer to gravity conveyors where operators place the castings, with proper fixtures and identification numbers,

Cast aluminum cylinder heads for 2,000-hp Pratt & Whitney aircraft engines are placed on lead-covered trays and rolled into the cabinet for x-raying. A pneumatically operated door is closed during exposure for protection of the worker. About 700 exposures are made per day

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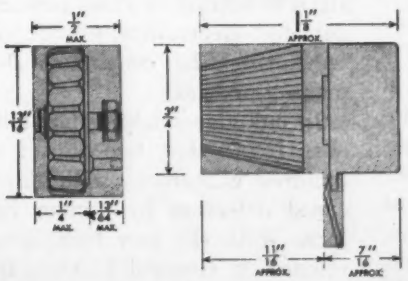

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on cassettes which hold the film. The castings are manually pushed onto the conveyor belt which carries them into the x-ray exposure chamber and out the opposite side according to a set cycle of operations. After radiography, the castings usually are stored in numbered bins until final disposition can be made after study of the x-ray films.

Two General Electric million-volt industrial x-ray units routinely inspect, in 16 minutes, the same number of steel parts that required 60 hours with low-powered apparatus. One of these units is in the $27,000,000 aircraft engine buildings at the River Rouge plant, which has been turning out 2,000-hp Pratt & Whitney engines, and the other is in a new steel foundry.

The million-volt unit at the aircraft engine plant is used to x-ray heavy steel castings, turbo-supercharger parts, and a wide assortment of bomber and glider castings for faults such as blow holes, tears, shrinkage cavities, inclusions and cracks.

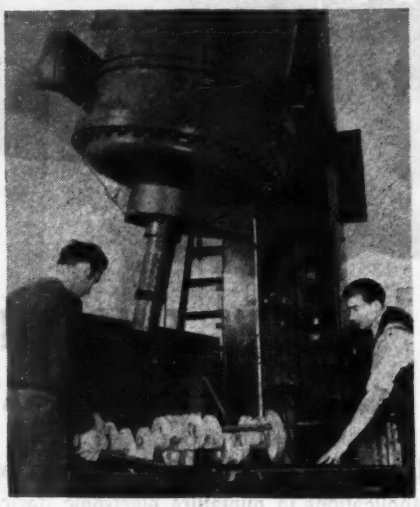
Ford engineers have found that the million-volt unit can examine 64 times the volume formerly x-rayed with their 400,000-volt unit, and 24 times the volume possible with radium of average amount in the same floor area and with the same handling facilities.

Multiple Inspection

Because of the large spherical angles available for useful radiographic examination with the million-volt apparatus, a large number of castings can be examined at each exposure. The limiting factor on the number that can be examined each day is almost entirely dependent upon the handling facilities. As many as 50 films have been simultaneously exposed.

The other million-volt unit in the steel foundry examines unmachined crankshafts for the Ford-built 500-horsepower tank engine, and also heavy castings for the M-8 light-armored car.

Every crankshaft built into a Ford V-8 tank engine undergoes radiographic inspection with the million-volt unit. Each shaft is three feet long and weighs about 250 pounds. To speed up examination, Ford technicians ingeniously designed a wooden fixture so that 12 of the big crankshafts could be x-rayed at one time. They are fitted into the fixture which is placed on



A crankshaft casting for a Ford V-8 tank engine being placed in position for x-raying by a General Electric million-volt industrial unit

a large lead-covered truck operating on tracks. Three different exposures are taken from different angles. The films in cassettes are placed in racks under points where the crankshafts are suspended in the fixture. The cassettes slide out quickly for changing. It requires 34 minutes to x-ray all 12 crankshafts one way. Another 18 minutes is necessary to radiograph separately two groups of six crankshafts each from a different angle. These two exposures take 36 minutes or a total of 70 minutes to completely radiograph all 12 crankshafts in three exposures.

After the films are developed, any defective crankshafts are removed for salvage, and the good ones are stamped with a star showing they have passed x-ray examination.

In the steel foundry, the designer and foundryman together use radiography in determining both the best design for the castings and the best way for producing it. Initial castings are radiographed and melting, temperature of the pour, location of gates and risers, ramming, shrinkage, and many other factors affecting quality are studied. The design itself, or the casting procedure, may be changed as a result. It has been found that by this method better castings are produced, with savings of time, materials, and money.

Crack Detector for Bottles and Jars

FLAWS, such as minute cracks and surface irregularities that prevent airtight sealing of glass jars, can be detected electronically without interrupting the continuous bottle-making process.

In one glass-making plant it had been found that two our of every hundred containers with flaws escaped detection by human inspectors. With the new technique, developed by General Electric in collaboration with Hartford-Empire Co., even those flaws barely visible to the naked eye are rapidly detected.

In operation, the containers automatically move in front of a phototube and are whirled rapidly under a strong light. Since the phototube is not affected by a steady light, the light reflected by perfect glass produces no effect. Any imperfection on the edge of the jar causes the lightbeam to flicker and this modulation of the intensity of the beam causes an electronic amplifier connected to the phototube to operate and cause the jar to be rejected.

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Project Engineer
North American Philips Co.

WAR INDUSTRIES that use audio frequencies in measurement work have use for a frequency meter that measures from ten to 50,000 cycles and that can be operated by non-technical personnel, after a few minutes instruction. To fit these requirements, engineers at North American Philips designed the unit illustrated for use in their plant.

The frequency meter they developed has sufficient power to operate a strip-chart recorder without an auxiliary amplifier regardless of voltage variations between 2 and 200 volts.

The input circuit consists of a

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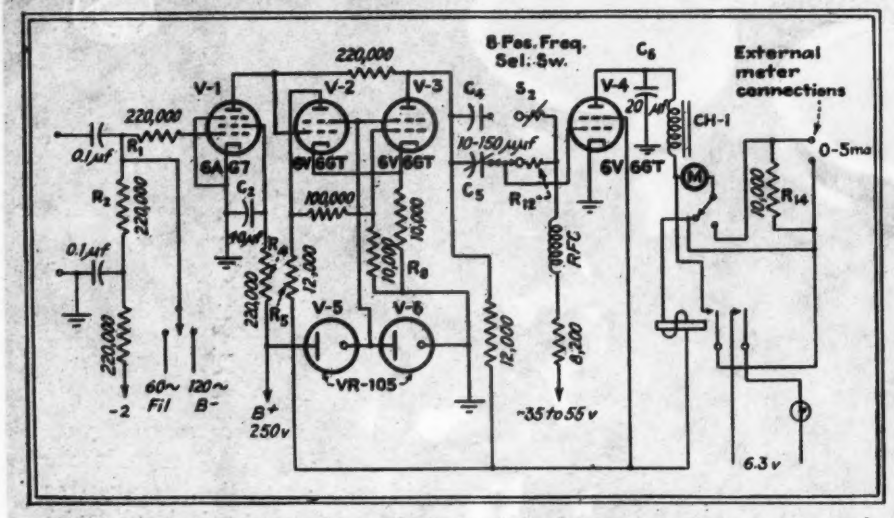
limiter as shown in the diagram. This stage employs resistor R_1 to bias the control grid of the input tube on the peaks of a cycle.

In clipping the peaks of a cycle, the output shows a square wave with steep fronts. The square wave results regardless of whether the input frequency is a pure sine wave or one with distortion and irregularities. In case of a badly distorted wave, the grid circuit will favor the predominant frequency over the lesser peaks by a ratio of about 3 to 1.



Circuit of electronic meter for production testing of frequencies between ten and 50,000 cycles. A linear direct-reading dial permits rapid reading by non-technical personnel

Floating Screen

Plate output voltage of tube V-1 is held constant by a floating screen grid. Since plate current changes are a function of screen voltage, increase of audio input voltage results in a decrease of screen voltage. This, in turn, is affected by the bias developed across R_1. Screen voltages reduce proportionately with increase of grid bias developed across R_1. Stabilization of screen resistor R_4 to ground, or B- with a bleeder resistor, would limit the range of constant output to a narrow band of frequencies. Capacitor C_2 is an audio bypass to prevent any part of the original wave shape from entering the plate circuit. The RC time constant of R_1 and C_2 is sufficient to delay any small part of the original wave from coinciding with the square wave, thus avoiding valleys and discharge peaks.

At V-1, a type 6AG7 was found to be best from the standpoint of high transconductance and high screen-grid wattage dissipation. The input sensitivity is slightly more than one volt, for almost all frequency ranges. Input impedance is greater than 100,000 ohms for most frequencies but not higher than the value of R_2.

Multivibrator as Amplifier

The multivibrator circuit formed by V-2 and V-3 is directly connected to the plate of V-1, and is at rest by virtue of bias-resistor R_9. The value of R_9 is selected to permit the multivibrator circuit to operate at the instant a square-wave voltage is present at the plate of V-1. The multivibrator circuit has no resonant characteristics; its function is to amplify the output of V-1 without alteration.

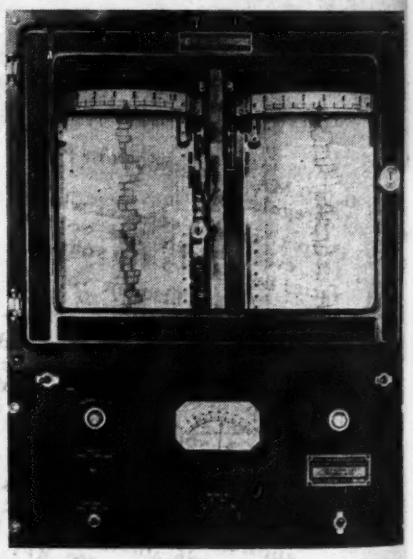
Amplified square waves are then fed into an RC integrating network (C_6,R_{12}, etc.) which determines the amplitude of the pulse that is to appear on the grid of V-4. Capacitors in the frequency-selector circuit are either air-type trimmers or silver-mica types having negative coefficients to minimize calibration drift caused by heat within the instrument.

Operation of the V-4 tube circuit is similar to class C audio amplification. The grid bias is adjusted to zero plate current with no signal input. This circuit functions as a linear amplifier in which plate current changes are directly proportional to grid voltages.

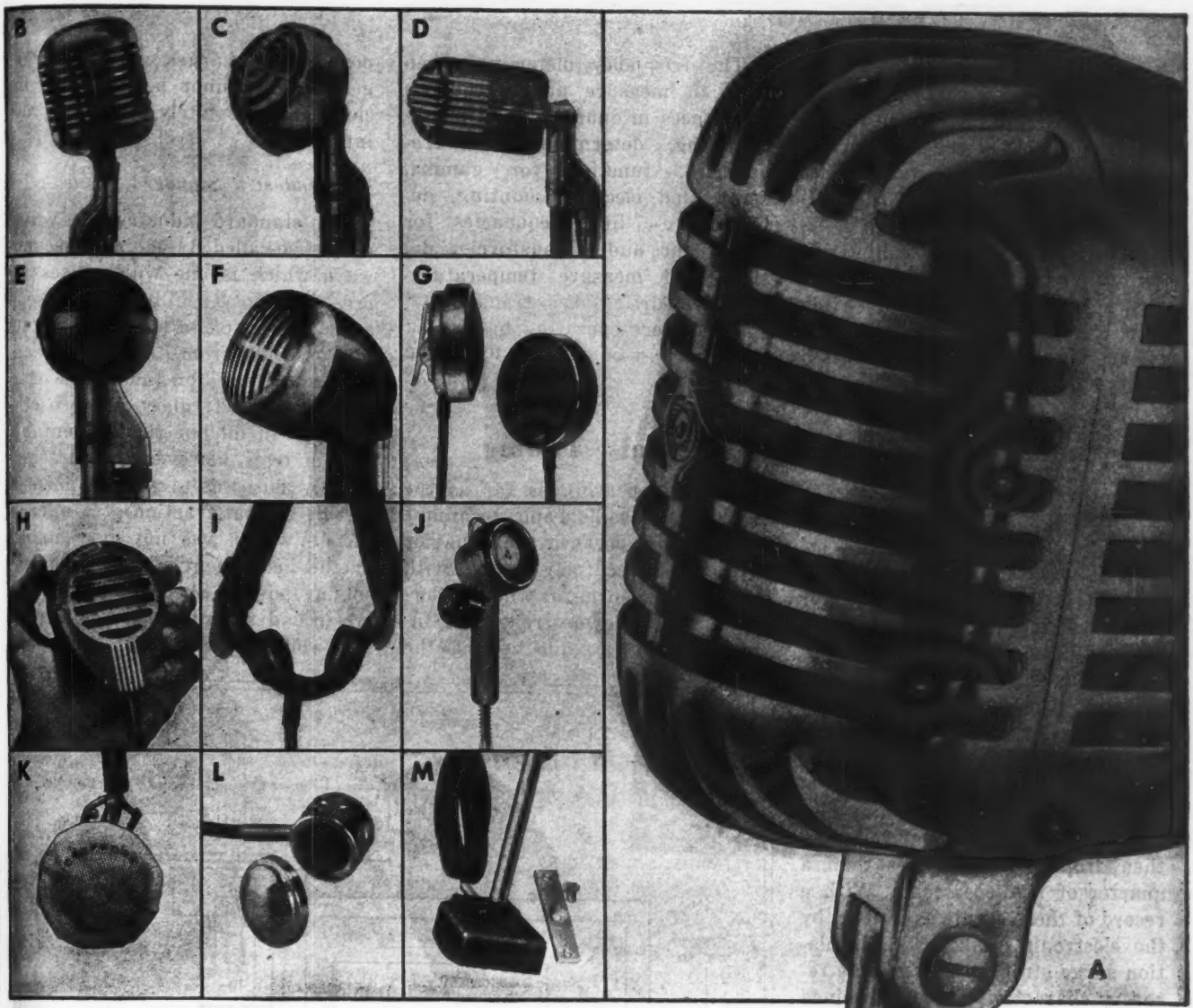
Safety Circuit

External and panel meters are protected from burnout by a relay in the plate circuit of V-4. The relay shorts the meter when current exceeds 10 ma and releases at about 4 ma. The meter circuit is arranged to permit reading the panel and external meters simultaneously. Accurate frequency indication on the external meter is only limited by the meter itself. If a recorder is used, overshooting and undershooting of the pen (determined by chart paper travel) must be taken into consideration. If the frequency meter is accurately calibrated and stabilized, the inherent circuit error will be less than 2.0 percent of full scale over the entire range of 10 to 50,000 cycles.

An RC network having a long time constant (C_6, CH_1) is incorporated into the plate circuit of V-4. Without the RC network, some recorder pens resonate badly at 100 to 130 cycles with the selector switch (S_3) set on 100 or 500-cycle positions. External meters having a 5-ma movement and a coil resistance not exceeding 1000 ohms may be used without recalibration. An external meter-damping resistor, R_{14} of 10,000 ohms, was chosen as an optimum value and accommodates most recorders without



The 5-ma recorder at the top of the photo is driven by the direct-reading frequency meter of the lower panel without an auxiliary amplifier



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affecting calibration.

For frequency calibration 60 cycles at 6.3 volts is obtained from the filament leg of the transformer and 120 cycles at 2.5 volts comes from the B-minus leg of the full-wave power rectifier through a 47-ohm resistor. The calibration switch is normally open (center position) as shown. Selector switch S_3 is placed on the 100 or 500-cycle range when making a calibration check.

The frequency meter has been used to measure audio-frequency differences in quartz crystal manufacturing, determine pulse frequencies, function for gamma, x-ray, and electron counting, determine a-c line frequencies for power and audio transformer design, and measure temperature-coefficient-drift on transmitters and receivers operating under test temperatures of from −40 to 200 deg F.

Industrial Oscillograph for Impulse Testing

By Otto Ackerman

Protective Device Engineering
Westinghouse Electric & Manufacturing Co.

The industrial electronic oscillograph is largely responsible for recent advances in design of aircraft engine ignition systems, high voltage insulation, circuit breakers, and lightning arresters. Investigation of the electrical phenomena associated with these devices requires the measurement of non-repetitive transients which may rise to a value of thousands of volts and then drop to zero in less than a quarter of a microsecond. With a record of these events as written by the electronic oscillograph, insulation surge strength and voltage recovery characteristics are obtained and designs are modified to give better service, longer life, and improved performance.

The high-voltage electronic oscillograph operates on the same principle as the sealed-glass-tube cathode-ray oscilloscope.

Sealed-off cathode-ray tubes up to 15 kv rating have been available commercially and equipment of this type is being used to some extent for impulse testing because it is relatively inexpensive. The extremely high voltages and rapid buildup rates used in modern testing methods have resulted in an ever-increasing demand for a recording instrument with a voltage and speed range far beyond that of the sealed-glass oscilloscope. To meet this demand, the streamlined Westinghouse electronic oscillograph shown in Fig. 4 was developed.

The high-voltage oscillograph is primarily useful in the study of single transients which are essentially non-repeating as far as the employable oscillograph technique is concerned because the behavior of the test piece may change with every applied surge, as when exploring the breakdown strength of insulation (Fig. 2), and because the powerful discharges of large surge generators cannot be obtained in close and absolutely regular time intervals.

Industry Standard Wave

The standard industry test wave is the so-called 1½-40 microsecond wave which is one which rises to crest in about 1½ millionth of a second and falls off to half value in 40 microseconds from its start. It can well be observed on the screen of a good sealed-off glass tube oscilloscope. In all but the elementary routine tests, however, the question usually arises as to what happened in this or that fraction of a microsecond which was not discernable on the instrument of the lesser resolving power. Such fractional micro-second records, taken with the high-voltage oscillograph, are pre-

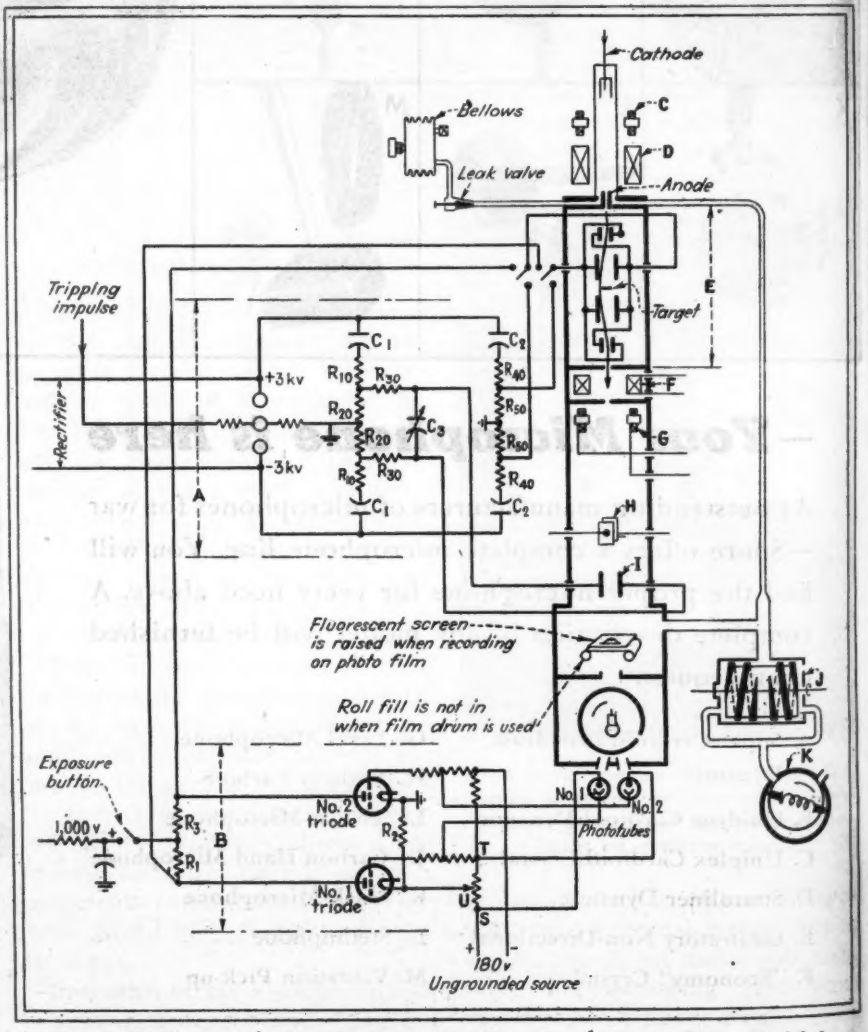

Fig. 4—Oscillograph body with timing circuits and pumping system. At (a) is the timing circuit for stationary film and at (b) the film drum exposure control whose operation is started by pressing the exposure button. Details of the instrument are: (c) upper deflecting coils, (d) upper concentration coils, (e) ray-blocking section, (f) main concentration coil, (g) lower deflecting coils, (h) measuring electrodes, (i) timing electrodes, (j) molecular pump, (k) rough vacuum pump

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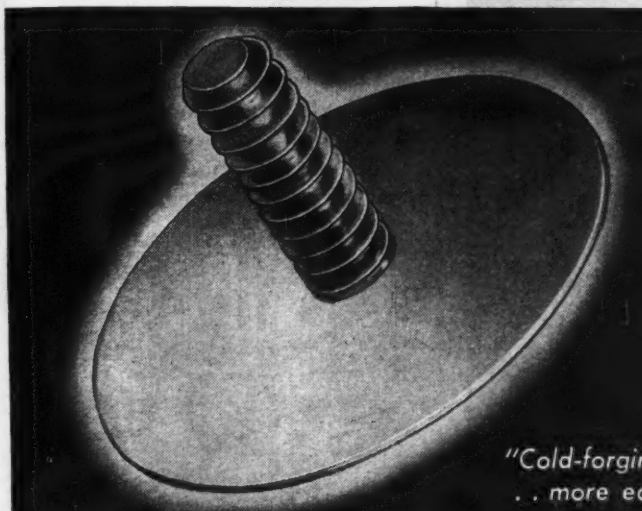

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sented in Fig. 2 and 3. They are taken on regular roll film 3⅝ inches wide. The film is exposed directly to the cathode beam; this eliminates the intermediate elements of fluorescent screen and optical system, which are essential with the sealed glass tube. The size of the picture renders enlarging unnecessary.

Timing Circuit

The timing of the cathode-beam release and of the beginning of the time axis are accomplished by a simple but very effective circuit (Fig. 4). The phenomenon under observation is connected to the oscillograph timing circuit through capacitance coupling with the center electrode of the double gap (Fig. 4). It should be noted that in all records of Fig. 2 and 3 the surge starts at exactly the same point with respect to the zero point on the time axis. This means that the action of the synchronizing circuit, including the double gap, is so consistent that no variations can be detected even at scales which ren-

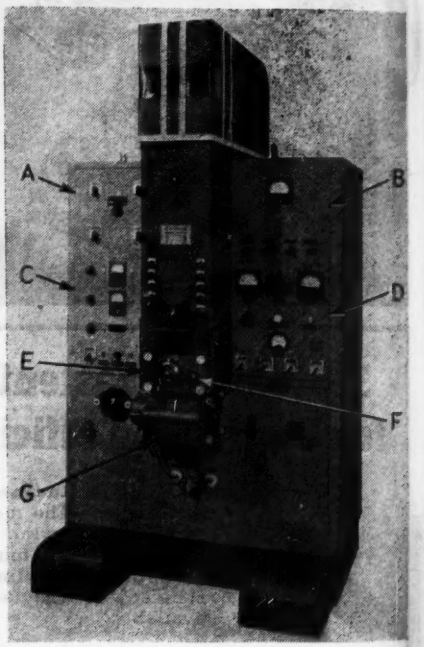
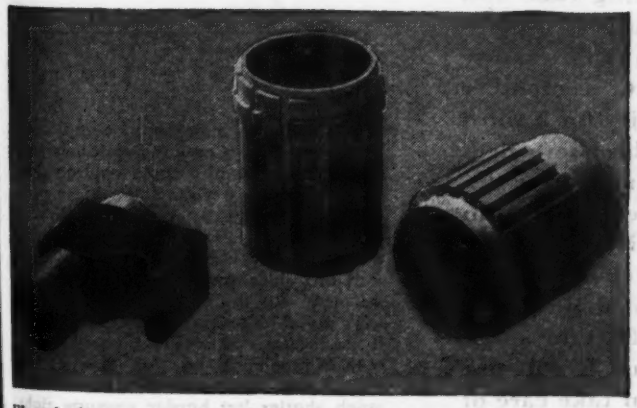


Fig. 1—Front view of Westinghouse electronic oscillograph. The sections are:
(a) Timing circuit panel for stationary film.
(b) Unit containing calibrating circuits and film-drum exposure control.
(c) Focusing and bias coil panel.
(d) High-voltage and vacuum control panel.
(e) Roll film operating knob and position indicator.
(f) Fluorescent screen hinge knob.
(g) Film drum attachment.

design picture!



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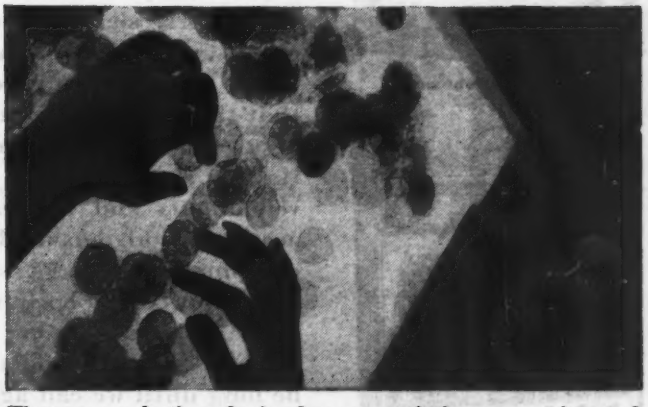

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der visible one hundredth of a microsecond.

The timing circuit for stationary film is shown at (a) in Fig. 4. A direct voltage of about 3 kv is applied to the outer electrodes of the double gap, whose spacings are set so that they are just above breakdown at this steady-state condition. The center sphere is normally at ground potential. Any disturbance in the circuit under test, such as the beginning of the surge to be measured, is transmitted to the center sphere through resistance or capacitance coupling. This sphere is temporarily thrown off ground potential which makes one of the gaps break down; flashover of the other side follows immediately as it now

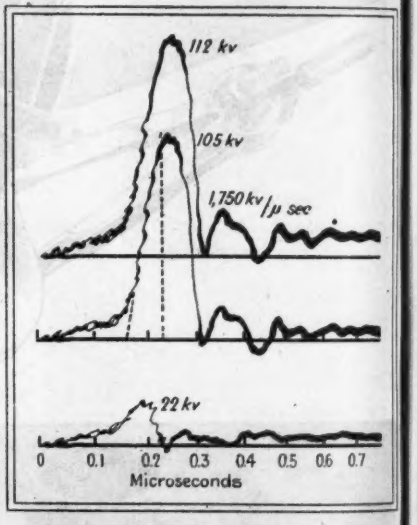
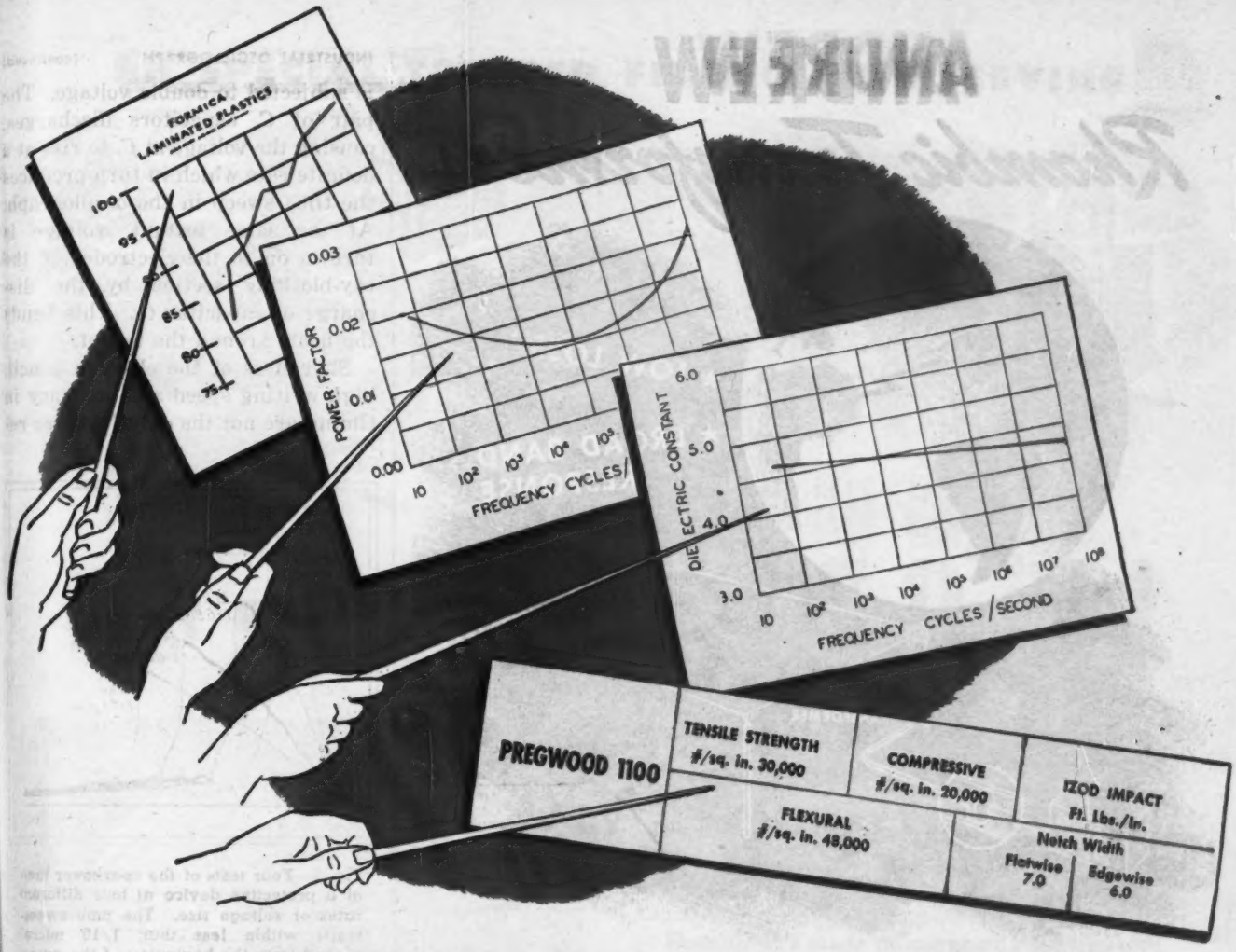


Fig. 2—This oscillogram of a dielectric strength test of a certain insulating part shows the effect of a rapid voltage rise. If a 60-cycle test voltage of 30 kv was applied to the specimen, flashover would occur along the outside surface. Such a test would invite the conclusion that the piece could not be punctured, but that the discharge would always take place along its surface. However, if the voltage is applied so fast that outside flashover has no time to develop, the discharge will force the much shorter but harder passage right through the material. On the first shot, the flashover occurred around the outside; the oscillogram discloses that the voltage had risen to 112 kv. At the second shot, no outside flashover was visible; the oscillogram shows it took 105 kv to puncture the material which probably had already been damaged by the preceding surge. The next oscillogram proves that the sample now definitely is punctured as the voltage collapses at 22 kv. This demonstrates that it takes a rate of voltage rise of about 1750 kv per microsecond to puncture this particular insulating member. This voltage rise is about 100,000 times as fast as that produced by the 60-cycle test and cannot be recorded by anything but a high-voltage oscillograph



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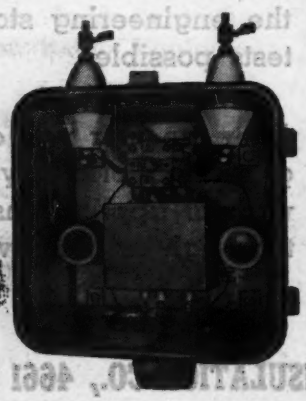

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is subjected to double voltage. The pair of C_1 capacitors discharges, causing the voltage at C_2 to rise at a definite rate which in turn produces the time sweep in the oscillograph. At the same instant, voltage is thrown on to the electrodes of the ray-blocking section by the discharge of capacitor C_3. This bends the beam around the target.

Sharpness of the electron pencil, high writing speed and accuracy in timing are not the only features required for high-quality recording. The oscillograms primarily must be true and free of distortion. In high-voltage laboratories, where voltages rise and collapse at the rate of hundreds of kilovolts per microsecond and where surge currents of thousands of amperes are discharged, spurious voltages and magnetic fields are a considerable problem. Their influence on the accuracy of measurements is reduced further if the measuring voltage applied to the deflecting plates is large in proportion to the spurious disturbances. A high voltage at the deflection plates in turn demands a much higher potential for generating the cathode beam because its speed, having been established by the cathode-anode accelerating potential, must remain essentially constant as it passes the fields of the deflecting electrodes; the latter should produce only a comparatively small lateral deflection. The measuring voltages would radically accelerate and retard it and deflect it beyond the limits of the recording space if they were of the same

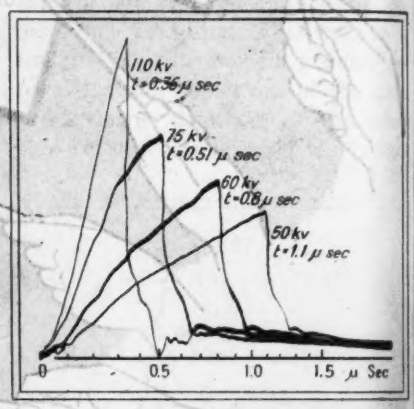

Fig. 3—Four tests of the sparkover time of a protective device at four different rates of voltage rise. The time sweep starts within less than 1/10 microsecond from the beginning of the surge

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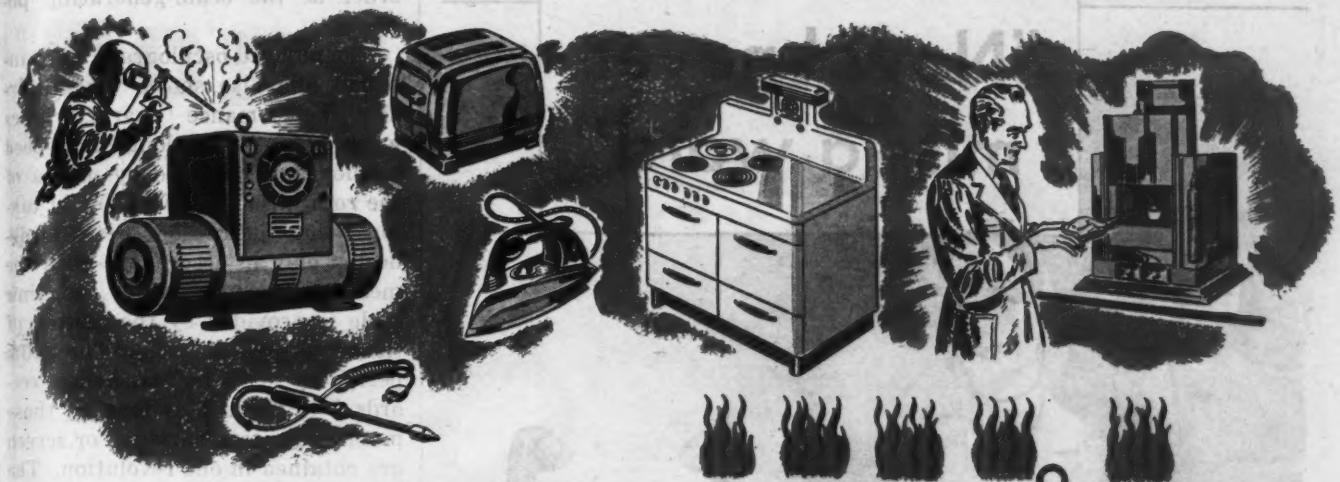

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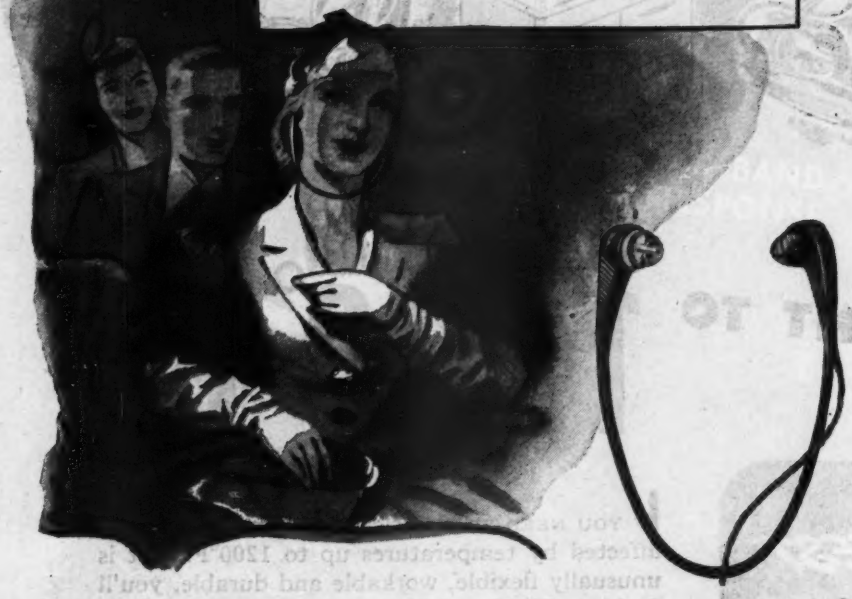

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order as the beam-generating potential.

The pumped oscillograph with internal film also shows very desirable performance characteristics when it is used for long high-speed oscillograms obtained by means of the rotating drum (Fig. 5). In taking them, the cathode beam is deflected only in accordance with the measured voltage while the time scale is provided by the motion of the motor-driven drum. The drum periphery is 18 inches; hence, records 5 to 6 times as long as those possible on stationary film or screen are obtained in one revolution. The time scale is by no means as fast as that possible with stationary film as the maximum speed permitted by

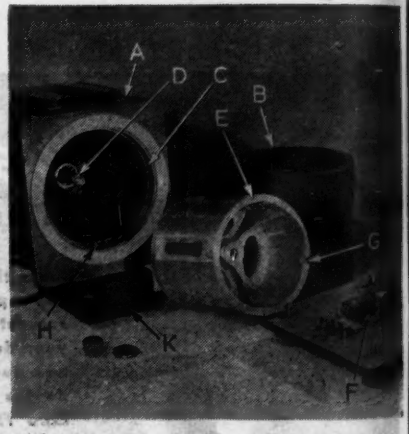

Fig. 5—(a) Film drum housing shown attached to the bottom end of the oscillograph in Fig. 1. Dark shield (b) is used to carry loaded film drum to oscillograph. Dark shield cylinder, containing the drum, is set into recess (c) and drum is pushed on to shaft (d). When dark shield is removed, drum is sealed against light by the close clearance between its rim (e) and the surrounding housing. For timing, light source (f), through slot (g) and tubes (h) will energize phototubes in container (k)

the strength of the film is about one inch in 1/2000 second.

If the rotating-drum method is employed with a sealed-glass tube, the image on the fluorescent screen must be photographed. With the time sweep remaining inoperative, the voltage deflection moves up and down along a fixed line. Therefore, the fluorescence due to one single deflection must be allowed to fade out before the same line can be retraced by the cathode beam. Otherwise, the oscillogram will be one continuous blur. Similar problems are encountered in television tubes and other field-scanning applica-

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tions and have led to the development of low-retentivity screen materials. The latter, however, have a much lower light output and require the application of tubes with different screen characteristics when changing from high-speed stationary to rotating film recording.

In taking film-drum records of highly irregular voltage phenomena, it is important that the film be exposed for not more than one revolution because otherwise the superposition of traces would render it illegible. Single-revolution exposure of the drum regardless of speed is accomplished by the application of phototubes in combination with the regular ray-blocking scheme of the Westinghouse instrument (Fig. 4). In the ray-blocking section of the

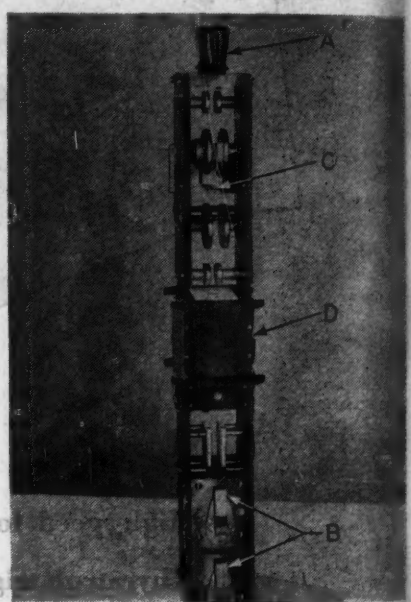

Fig. 6—By means of handles (a) temporarily inserted into its top plate, the frame carrying all beam deflecting elements can be pulled out of the oscillograph tube. Contact springs (b) connect the various electrodes to the bushings in the housing. Most parts can be identified by reference to Fig. 4. (c)—Target. (d)—Magnetic shield around main concentration coil

oscillograph tube, a metal tongue or target bars the electron beam as long as it is not deflected from the centerline of the instrument by a potential difference between the electrodes located above it. If a sufficient field develops between these electrodes, the beam moves off the target and an identical set of plates below the target brings it back on the centerline.

When closing the exposure button (lower corner of Fig. 4), the same

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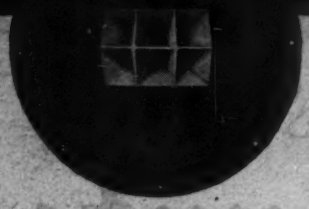

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potential of about 1000 volts is applied to all ray-blocking electrodes; there is yet no field between them and the beam remains cutoff. However, when the slot in the rim of the rotating drum permits light from the lamp inside the drum to strike phototube No. 1, the negative bias of triode No. 1 collapses and the circuit branch R_1, R_2 carries current. The voltage drop across R_1 now unblocks the beam. At the same time, the voltage drop across R_2 raises the level of the voltage source which first kept the grid of triode No. 2 strongly negative. Now, when phototube No. 2 is energized again by light through the slot (one revolution after the process was started in No. 1), the collapse of its potential is sufficient to make the grid of triode No. 2 positive. This starts current through R_2 which practically cancels the potential difference between the opposing ends of R_1 and R_2 and hence retraps the beam.

Construction

The cathode tube of the unit is constructed of seamless steel tubing joined with high-grade iron castings; the latter are visible in front of the center of the steel cabinet. They contain the rotating film drum, the stationary film holder and the fluorescent screen. All accessories, including the 50-kv cathode voltage supply, are housed in the same cubicle. The pumps, consisting of an oil pump for the fore-vacuum and a mechanical, grooved cylinder-type molecular pump, exhaust the instrument in about 10 minutes to a hard vacuum at which no discharge can form between the anode and the cold cathode. The latter consists of a small aluminum cylinder without any heater. The electron pencil is formed through ionization by collison. This requires a definite gas pressure which is controlled by air admitted through the leak valve. The latter reduces air of atmospheric pressure to the required vacuum which ranges from 5 to 15 microns depending on the desired beam current. Despite the high reduction in pressure accomplished with the valve, the latter is very sensitive to small changes in atmospheric pressure. Small variations of the intake pressure can readily be produced by taking the

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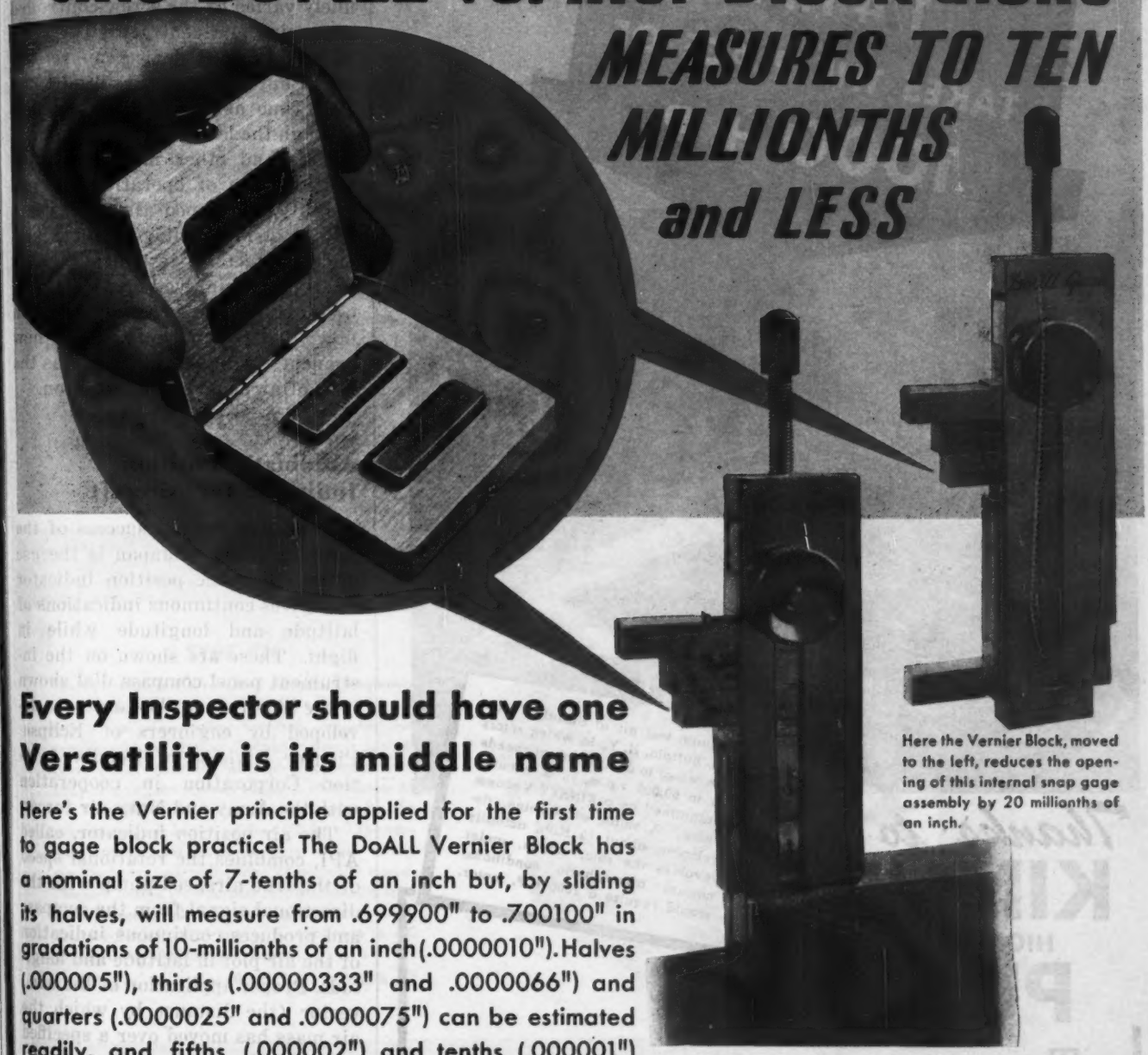

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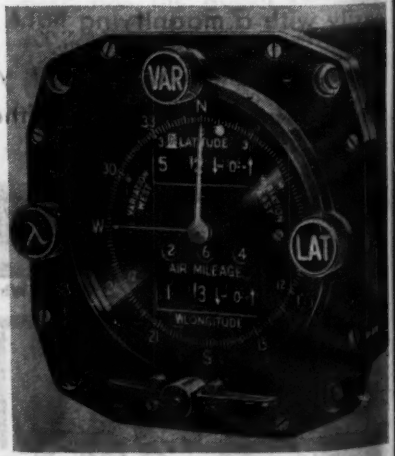
• • •

Automatic Position Indicator for Aircraft

ONE REASON for the success of the bombing raids on Japan is the use of an automatic position indicator that gives continuous indications of latitude and longitude while in flight. These are shown on the instrument panel compass dial shown in the illustration. The unit was developed by engineers of Eclipse-Pioneer Division of Bendix Aviation Corporation in cooperation with the Army and Navy air forces.

The air position indicator, called API, combines the rotational speed of the true airspeed pump with the directional signal from the compass and produces continuous indication of the air plot in latitude and longitude. Proper application of the wind vector (the distance by which the air mass has moved over a specified



Closeup view of the panel indicator showing the counters for latitude and longitude change and air mileage

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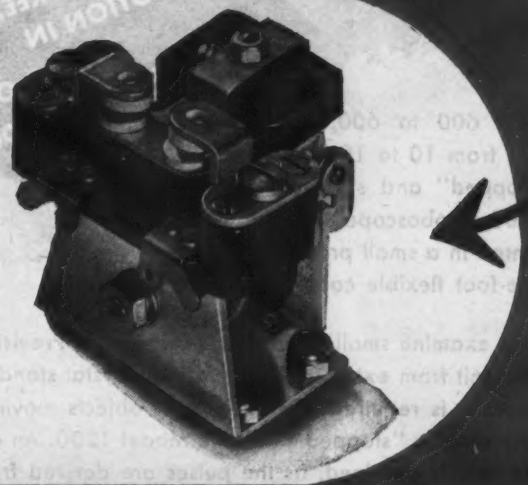

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The CN relay is the result of advanced engineering technique and succeeds Allied's successful AN type . . . a power relay expressly designed for breaking heavy current. Contact rating is 50 Amperes at 24 Volts DC with silver contacts; with alloy contacts the contact rating is 75 Amperes at 24 Volts DC. *(The latter arrangement with the alloy contacts is known as the CNS type.)* The contact arrangement is single pole, single throw, double break, normally open or normally closed. The new design incorporates molded Bakelite insulation, greater electrical clearance and over-all improved mechanical structure. Available in AC or DC. Complete data on request.

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period of time) to this air position yields ground position. The readings of latitude and longitude appear on the two drum-type counters, which are initially set to the proper latitude and longitude of the take-off point and can be reset anytime when passing over a check point in flight. The indicator, more specifically called the computer, also registers total air miles traveled and has a compass dial and pointer which must necessarily indicate heading with respect to true north.

Corrections

Operation of the instrument consists of checking the compass, energizing the API, and setting the counters to the proper latitude and longitude before take-off. During the take-off run, the true airspeed pump begins to operate at about

API installed on a typical aircraft instrument panel to provide continuous readings of latitude and longitude

seventy or eighty miles per hour, and the API then swings into operation. Magnetic north variation must be set in manually a degree at a time as the flight progresses, in order that the compass input reference is true north for resolution into geographic coordinates.

Wind can be determined by the API itself by noting the difference in air position as read on the API and ground position as determined by a check point, after flying for about forty minutes from a point where the API was set to ground position. The wind thus determined can be used for future flying

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The pressure generated by the pump is fed into one diaphragm in the controller. The other diaphragm in the controller receives pitot pressure, and together these two control a switch to the driving motor in the pump. In attempting to keep the pressures in these two diaphragms matched, the pump speed varies with pitot pressure, and in doing so its speed of rotation is directly proportional to true airspeed.

The rotational speed from the pump motor is fed into the computer, which employs the well-known ball-disk integrator scheme. The pump motor actually drives two disk-plates, one for latitude and one for longitude. The latitude disk plate drives by friction a ball, which in turn drives a cylinder geared directly to the latitude counter. The speed and direction of rotation of the cylinder, and of the counter, is directly proportional to the speed of the disk plate and the radial position of the ball on the disk plate. This radial position is determined by the input compass signal through the API amplifier. The latitude counter is driven in a similar manner.

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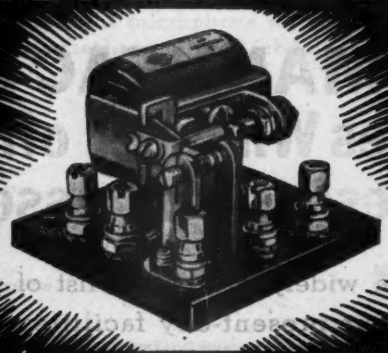

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POSITION INDICATOR (continued)

position indicator gives the navigator a continuous indication of his air plot. However, it cannot be called an automatic navigator and was never intended to replace the navigator. Its purpose is to act as an aid to the navigator, to do his job of dead-reckoning for him when his other means become impossible as during evasive action, to carry on for him over limited periods of time when he must leave his work to do other jobs such as operate guns. Such other functions include keeping account of distance traveled between celestial shots, determining winds, and aiding in computing gasoline consumption and range. It can also be used on long straight flights but is really not necessary because of the simplicity in performing such a task with elementary instruments.

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50,000 Hours for C-R Tube

INSTALLED IN the WCAE, Pittsburgh, transmitter in August 1939, an RCA type 904 cathode-ray tube is still operating as well as it did five and a half years ago.

At WCAE, Pittsburgh, chief engineer James Schultz shows the long-life cathode-ray tube to J. H. Keechle of RCA. Installed more than five years ago in the modulation monitor, the tube still provides clear patterns on its screen

This amounts to a service record of 50,000 hours, better by a year and a half the service given by the previous RCA 904 tube, the original tube installed in the transmitter in 1935. This tube operated continuously for four years and was then replaced by the present tube which had been held as a spare replacement.

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TUBES AT WORK

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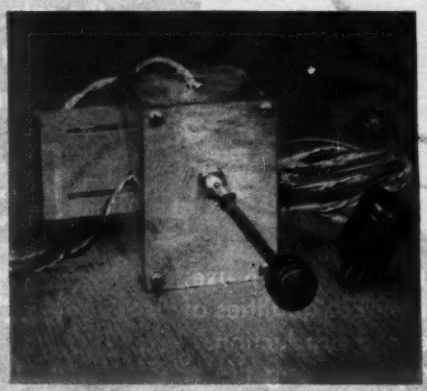
Adapting Present F-M Receivers to Tune Proposed FCC Allocation

NEW CONVERTERS for receiving the proposed f-m band from 84 to 102 Mc were the subject of much discussion at recent FCC hearings in Washington. Factory-built models include a one-tube and a three-tube unit. FCC engineers showed a two-tube design whose circuit is given below.

The one-tube converter contains a single 7S7 tube and can be installed in the cabinet of most f-m sets. The r-f input feeds a band-pass filter in place of a continuously tuned circuit and the oscillator section is operated at a fixed frequency. A switch, to be mounted on the receiver panel, connects different values of capacitance into the band-pass and oscillator circuits of the converter to provide two fixed-tuned receiving frequencies. With the switch in one position, tuning from 84 to 92 Mc is accomplished by varying the regular receiver dial so that the receiver acts as a tunable i-f stage. Setting the converter switch to the second frequency position permits tuning from 93 to 102 Mc. Power for the converter tube is obtained from one of the output tube sockets by means of an adapter. Designed and built by engineers of Hallicrafters Company, the unit would sell for about $5.60 in quantity to a single buyer, fob Chicago. This price does not include Federal or state excise taxes.

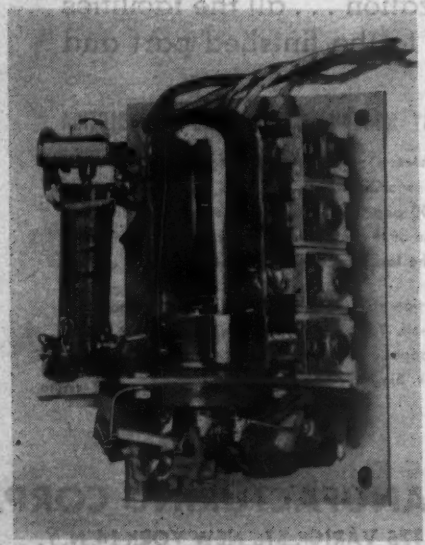


Complete one-tube converter for receiving stations in the proposed f-m band from 84 to 102 Mc. Fixed-tuned, the switch selects either of two frequencies so that further tuning is done with f-m receiver dial

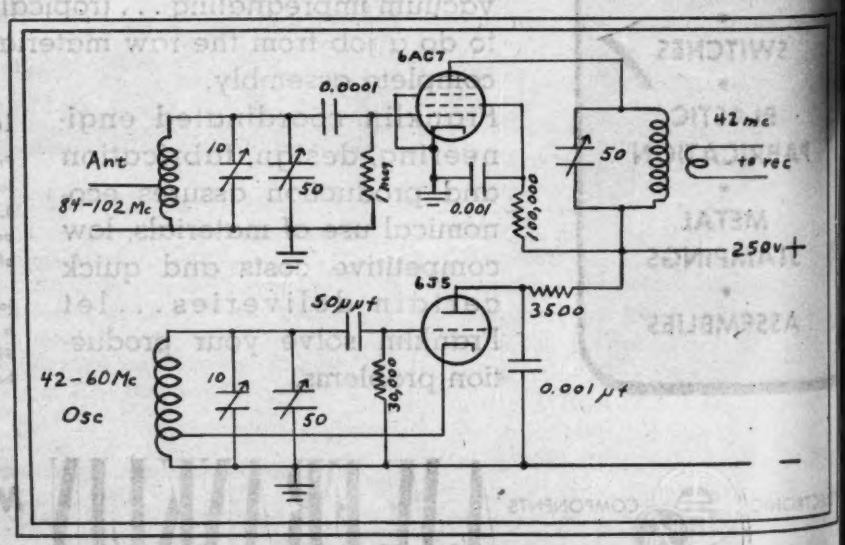
The experimental three-tube model contains a 7V7 mixer, a 7A4 oscillator, and a 6X5GT/G rectifier. This unit has its own continuously tuned circuits with the oscillator tracking 42 Mc below the mixer frequency. Output of the converter feeds into the antenna terminals of the f-m receiver which is left tuned to 42 Mc while receiving stations between 84 and 102 Mc. Hallicrafters estimate that this model could be built for $11 fob Chicago whenever the priority situation permits.

Future of Citizens Radiocommunication Service

THE FEDERAL Communications Commission proposal to allocate the band from 460 to 470 Mc to a new radio service for civilian use was prompted by the success of the walkie-talkie type of short-range radio communications equipment used on the battlefront and the possibilities for its varied peacetime uses. According to FCC chairman E. K. Jett, "the proposed service will be thrown wide open to any citizen, whether he be an individual who may want a portable suitcase-type set for his own purposes or whether it be a department store, or laundry, or farmer, a taxicab concern, bus, or anybody else." In

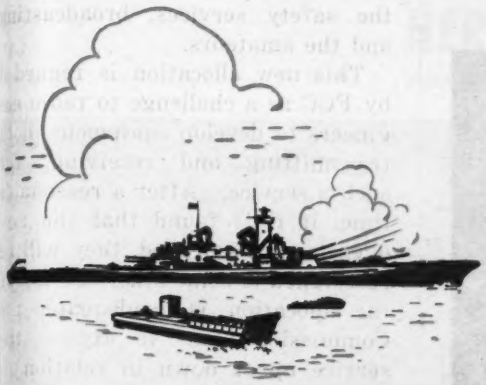


Compact construction of the one-tube converter of Hallicrafters Company



Mixer and oscillator circuits of a 2-tube converter shown by FCC engineers. The two 50-μf variable capacitors are used for tuning and have a common shaft

"Try this on your BIG GUNS!"



Crouching in an old shell hole on shore, a fire control party directs a battleship's deadly salvos against enemy strong points holding up Allied invasion forces. On the world's far-flung fighting fronts, battle-tested Spencer precision wire used in communication equipment is hastening the day of final Victory.

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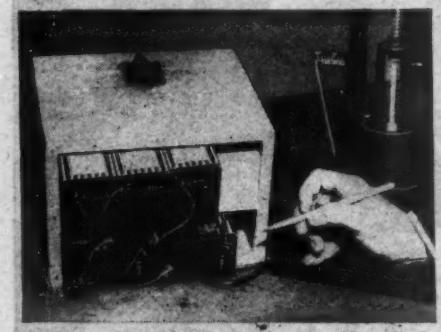

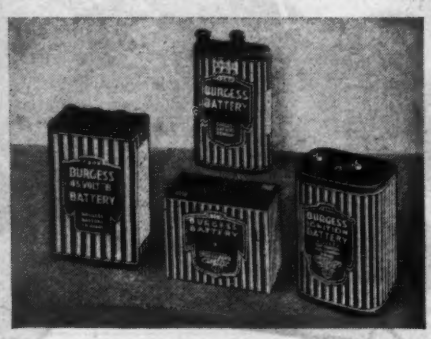

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the past, it has been necessary, because of the limited number of frequencies available, to grant frequencies only to common carriers, the safety services, broadcasting and the amateurs.

This new allocation is regarded by FCC as a challenge to radio engineers to develop equipment, both transmitting and receiving, for such a service. After a reasonable time, if it is found that the frequencies are not used, they will be reassigned to some other service. If the allocation is inadequate, the Commission plans to expand the service up or down in relation to its proposed spot on the spectrum. It is also recognized that the bandwidth may be reduced later on, if necessary. The operating standards can be reduced considerably below those necessary for commercial or safety services because it is offered as a service "for convenience".

Four Possibilities

The Commission has stated that the possible uses of the service are as broad as the imagination and the ingenuity of equipment manufacturers can devise. Commissioner Jett envisions developments along these lines:

(1) A handie-talkie for battery operation (fraction of a watt), light in weight, not much larger than a small camera, small antenna that can be pulled out a foot or so, placed at side or in hand, and useful for a very short range. The range would be a mile or two. An example of its use would be on a farm to communicate with a tractor. This equipment probably would use dry batteries but it could use storage batteries.

(2) A walkie-talkie, the size of a small suitcase, will weigh from 20-50 pounds. There will be different types—some with handles, some for mounting in autos or boats. May use storage batteries (2 watts or so) and can be recharged from house current. If built in autos or boats, it can be recharged as radios in autos are today. Example of use: Express Company might want to change order of trucks loading at platform and could use walkie-talkie to order certain trucks to the front. Also

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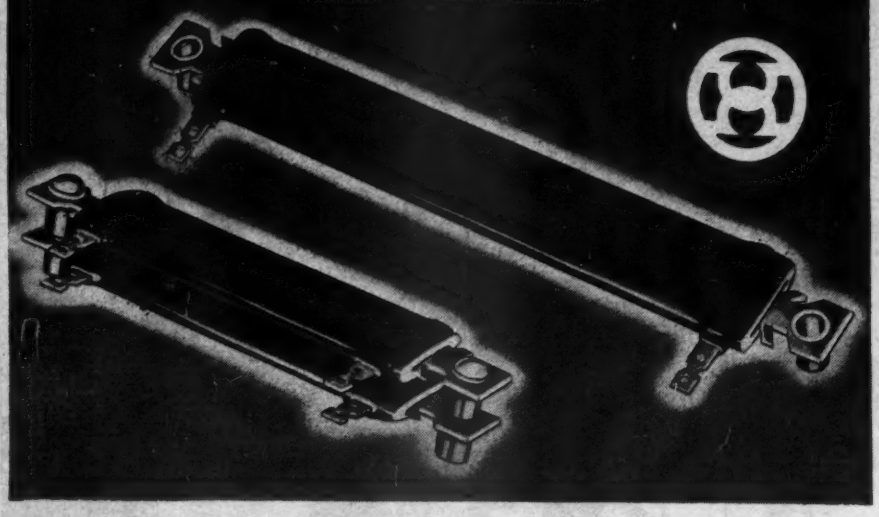

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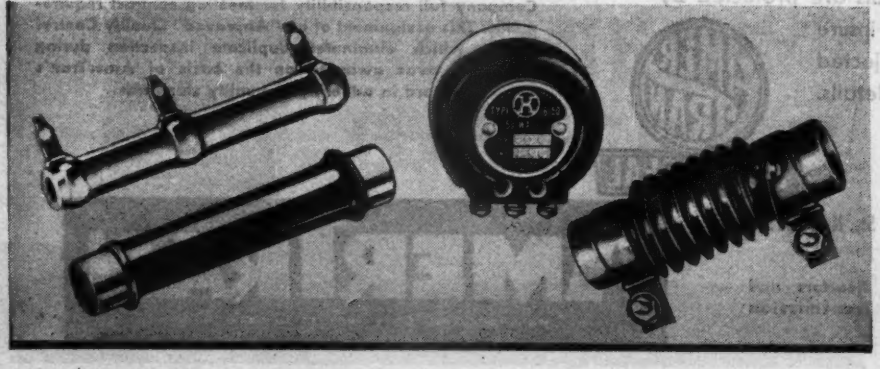

gas-filling stations or country stores might have calling stations. The range of the walkie-talkie is 5 to 8 miles, depending on the terrain.

(3) Larger equipment would have elaborate antenna, for installation at a fixed location, such as the roof of a department store, laundry, dairy or office building. It would afford communication between fixed points.

(4) Portable equipment, which will include a broadcast receiver, and be about the size of a walkie-talkie. Since it will be necessary to have an audio system in the walkie-talkie to take care of the two-way personal communication service, Mr. Jett sees the possibility of including a radio-frequency unit to provide for the reception of standard or f-m broadcast signals. The equipment could be used not only for two-way communication, but also as a broadcast receiver. An alarm system, remote control systems and other devices might be added to equipment to meet particular needs.

As in the case of the amateur service, the Commission proposes to assign no channels within the band. By use of comparatively simple circuits already known, the Commission believes that it should be possible to provide both transmitters and receivers tunable over all of the 460-470 Mc range, emitting signals sharp enough to minimize interference.

Citizens Radio League

It is recognized that if a large number of people operate transmitters in the same community there is bound to be interference. The suggestion is made that a non-profit, citizens radio league be organized to assign local operating frequencies. For example, citizens in a certain community might get together and decide that department store No. 1 will use channel No. 5; department store No. 3 will use channel No. 19; laundry No. 2, channel No. 7, etc.

Interference Problem

It is hoped that frequencies, because of their characteristics, may be duplicated throughout the U. S. without a great deal of interference. With low-power devices used on the

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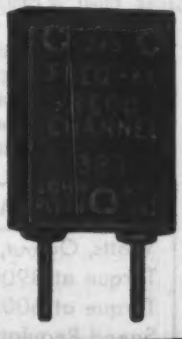

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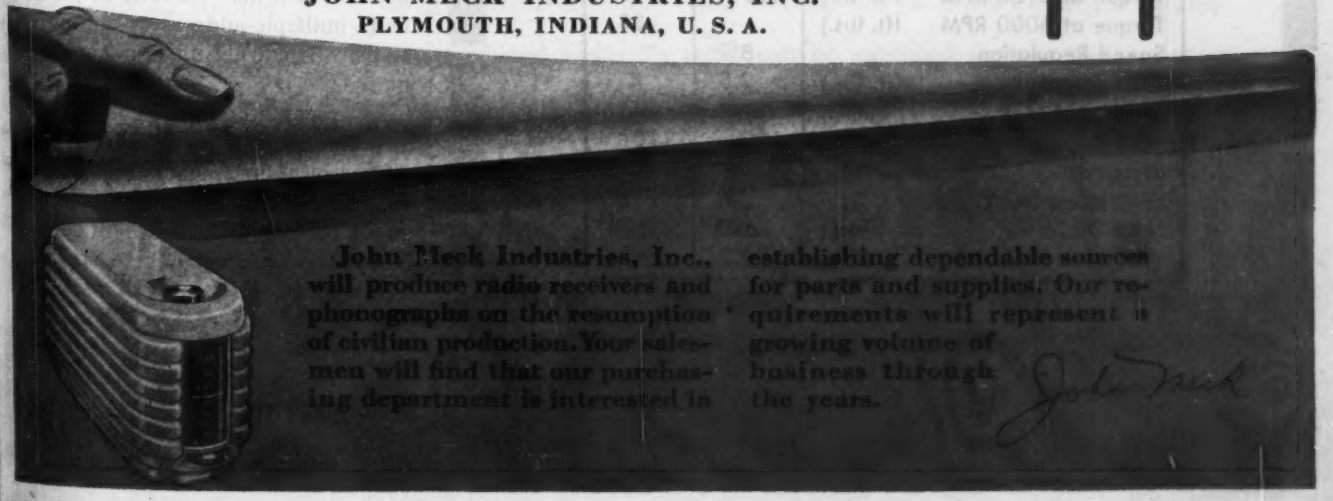

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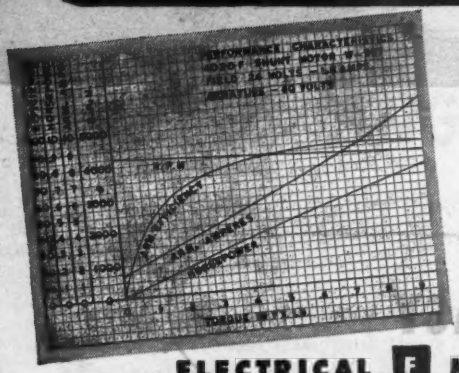

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4000 FRAME MOTORS		4020 Shunt	4020 Series
Watts, Output, Con.	(Max.)	375	746
Torque at 3900 RPM	(ft. lbs.)	.65	1.4
Torque at 6000 RPM	(ft. lbs.)		.88
Speed Regulation		8%	
Lock Torque	(ft. lbs.)	2.5	4
Volts Input	(min.)	12	24
Volts Input	(max.)	110	110
Diameter		4"	4"
Length Less Shaft		7⅛"	7⅛"
Shaft Dia.	(max.)	.625"	.625"
Weight	(lbs.)	9.2	9.2

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ground, the range will probably be from 2 to 15 or 20 miles depending upon the terrain. If one is high on a hill with an unobstructed path of 25 or 30 miles, the range will be even greater. On the other hand, if one is down in a valley, the useful range would not be more than a couple of miles. "Boosters" or automatic relay installations will be permitted where necessary. Most transmitters on this band are likely to be of low power and will not need extreme antenna heights. In rural areas where there is no interference, higher power may be permitted.

The Commission makes it clear that common carrier operation in the citizens communication band will not be permitted and no charge can be made for the licensed facilities or for transmission of messages.

License Requirements

Only the minimum requirements of the Communications Act with a few minimum traffic rules will be set up by the Commission. Operator licenses will be granted to American citizens only and no technical knowledge will be required. It is proposed to issue a license to run for five years. It will be printed probably on a pocketbook size card, the operator's license on one side and the station's license on the other. The only qualification for the operator's license will be certification by the applicant that he has read the rules and regulations of the Commission and understands them. Station licenses, according to FCC's present plans, will be limited to "point-to-point, fixed point-to-mobile, mobile-to-mobile, and multiple-address communications. Broadcasting is not contemplated."

In recent hearings before the subcommittee of the House Committee on Appropriations, Commissioner Jett was questioned as to the effect of this proposed new service on the local telephone. He said that he does not believe it will ever take the place of the local telephone, and reports he has had to date indicate that telephone officials are enthusiastic about the possibilities of the service. There is a maintenance cost to be considered in the pro-

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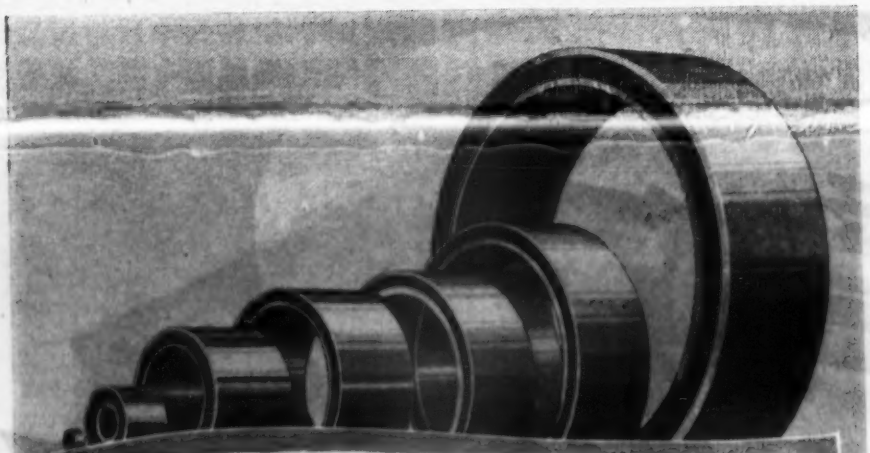

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Torflex Bearings consist of a seamless tube of rubber which has been stretched between two concentric metal tubes assuring high radial pressure which provides the required adhesion between the rubber and metal. Torflex Bearings take axial, torsional and radial loads. They absorb vibration, provide flexibility for cushion and misalignment, transmit torque, suppress noise, eliminate wear and friction and are being made in a wide range of sizes to carry loads from ounces to tons.

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posed citizens radiocommunication service. Considering that there must be two transmitters and two receivers to carry on two-way communication, it will average much more than the cost of subscribing to telephone service. However, there are many places in the United States without telephone service, and many needs that telephone service cannot fill.

Don't look for citizens radiocommunication service to be licensed until after V-J Day.—G.T.M.

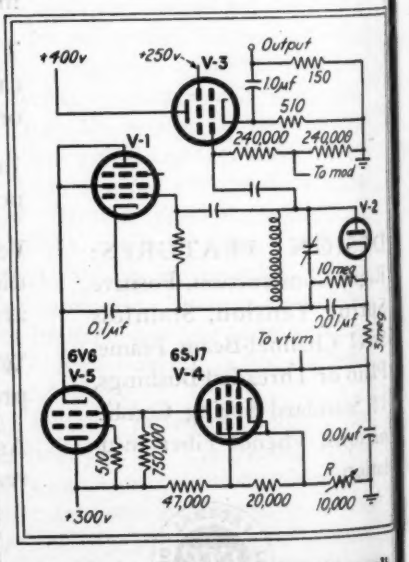
• • •

Wide-Range Signal Generator with Automatic Amplitude Control

By HOWARD T. STERLING

AFTER EXPERIMENTING with various types of amplitude control for L-C oscillators involving shunting of the tuned circuit, with results not wholly satisfactory, the following scheme was worked out with much better success. It was inspired by the use, in General Radio's model 605 signal generator, of plate voltage control to set oscillator output to the desired amplitude.

Referring to the circuit illustrated, the output of the oscillator, *V*-1, is rectified by the diode, and



Circuit of a system of automatic amplitude control of an oscillator in a signal generator

the positive voltage resulting is fed to the grid of *V*-4. This tube is operated at low current, the variable cathode resistor *R* providing sufficient bias despite the positive

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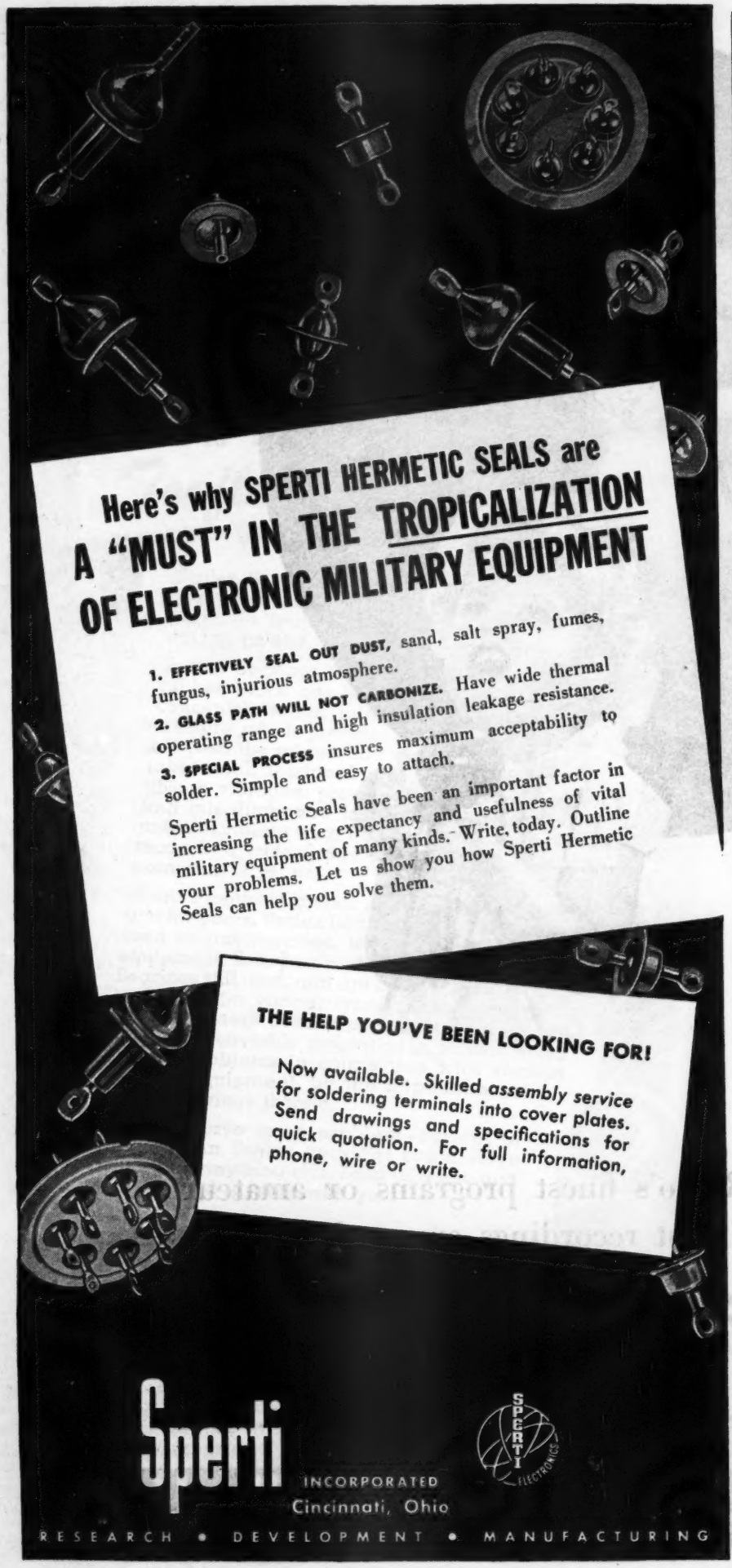
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voltage at the grid due to oscillator output. Variations in oscillator output are amplified by V-4 to control the bias on V-5 and hence the oscillator plate voltage.

The signal voltage at V-4 grid can be applied to a vtum to read oscillator (and signal generator) output. Since the control depends upon change of amplitude, regardless of the level, it will be seen advisable to operate the oscillator at a relatively high level. In practice, twelve to fifteen volts peak was found most satisfactory. With a fairly high-Q variable capacitor (such that amplitude does not fall below this value at the low-frequency end of a band) the output of the generator can be kept constant plus or minus 2 percent from 50 kc to 50 Mc.

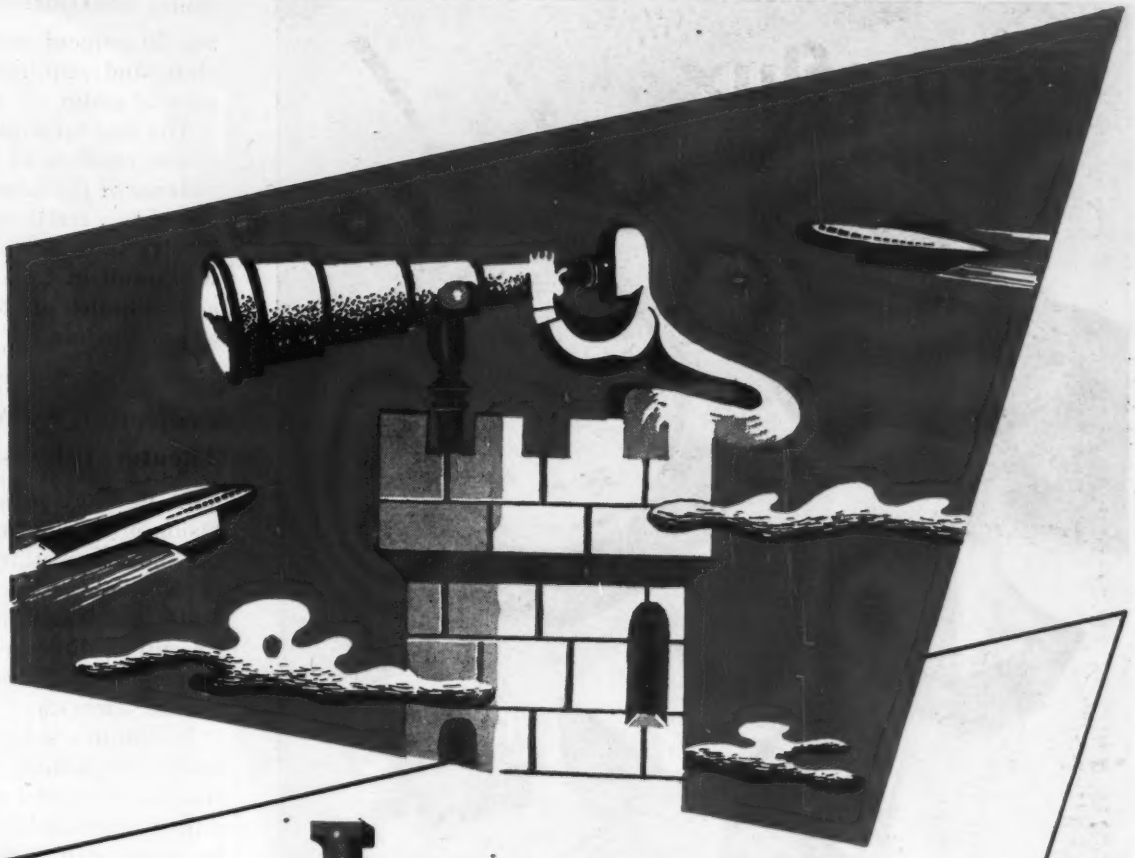
The tube finally chosen for V-1 was a 6AC7. Everything from a 6J5 through a 6L6 was tried, but the 6AC7 behaved most consistently and provided highest output. Any convenient diode can be used for V-2. A 6L6 was used at V-3 for high output.

Power Supply

The oscillator plate and V-4 screen supply should be regulated, although it is not entirely necessary. The control circuit is essentially degenerative so that the output will not vary much with change in the line voltage. The screen potential on V-4 will affect the gain of that stage, though the plate voltage need not be regulated. Tube V-4 and its associated bleeder draw about 5 ma and this is the only additional plate current drain introduced by this control circuit.

Any doubts as to the advisability of changing the plate voltage of the oscillator may be set at rest; the resulting slight shift in frequency is far less than the one-percent tolerance that must be expected in the best of wide-range signal generators.

The output can be adjusted by R; in practice this should be set and locked, although a vernier control of comparatively low resistance may be placed in series with it and brought to a knob on the panel to correct for residual amplitude changes of one and two percent if desired. With distortion, 100 percent modulation of V-3 is possible,



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but 50 percent modulation is very clean and requires about 15 volts peak of audio.

The line termination at the generator consists of the cathode impedance of the tube and the 500 and 150-ohm resistors in parallel. Twelve volts r-f to the grid of *V*-3 will result in 2.5 volts output with a termination of 73 ohms at the far end of the line.

• • •

Projection Systems for Theater Television

TWO METHODS of large-screen television projection were described at the March meeting of the Society of Motion Picture Engineers, Atlantic coast section, by Dr. A. H. Rosenthal, director of research and development of Scophony Corporation of America.

To obtain a screen image of maximum brightness it is desirable that the elemental picture image be either intensely bright, or that it be moderately bright for a long period of time. To obtain great brilliance of the picture element in systems in which the modulated electron beam produces the light directly through fluorescence, as in cathode-ray tube television projection, it is necessary to sacrifice definition in the interest of exciting an appreciable area of the fluorescent material. Thus this method of picture projection has an inherent limit of brilliance-to-definition ratio.

Optical Gate and Image Storage

A more satisfactory method of television projection, according to Dr. Rosenthal, is to use the signal not to produce the light, but to modulate an independent light source. This source can be as bright as need be. Standard motion-picture projector light sources such as carbon arcs or mercury pressure lamps can be used. In fact, this method of light modulation is analogous to film projection wherein the film density modulates the light passing through the optical system.

However, in film projection all picture elements are actively modulating the light simultaneously and for an appreciable portion of the total frame time. In television

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technique, where it is necessary to dissect the frame into successive elements and transmit them row after row, only one picture element would normally be modulating the light beam at a time, and thus the duration of projection of each element would be much less than that in standard motion-picture projection. To make up for this loss in available projection time, some method of storage for the picture elements is needed at the television projector over and above that necessary to avoid flicker.

Storage increases the practical throw of the projector. In one installation where adequate screen brightness was obtained with an 8-inch throw without storage, with a storage ratio of ½ (that is, the elements were retained by the projection system for half of the frame scanning time) the throw was increased to 200 feet (comparable to that in drive-in theaters) with the same screen brightness.

Supersonic Diffraction Valve

The first of the systems described to accomplish these objectives made use of the modulation element illustrated in Fig. 1. A quartz crystal vibrating in the supersonic range sends traveling compression waves across the fluid light gate. These waves are completely absorbed by the terminating window to avoid standing-wave patterns in the fluid. The compression waves cause the light to be diffracted. Standard optical-bar systems are used to obtain an amplitude-modulated light beam from the diffracted rays by selecting the diffracted beams. The system is linear.

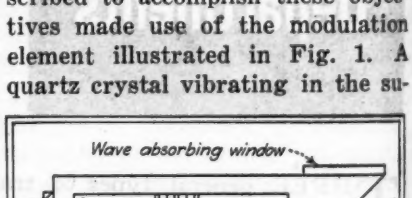

FIG. 1—Liquid light gate makes use of diffraction variation in the fluid, produced by amplitude-modulated supersonic vibrations, to control the intensity of light projected to the screen

The supersonic vibrations of the quartz crystal are amplitude modulated by the television signal. As these amplitude-modulated waves

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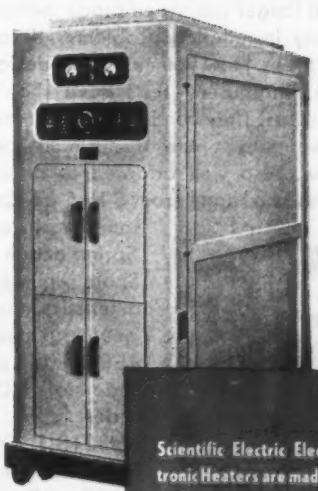

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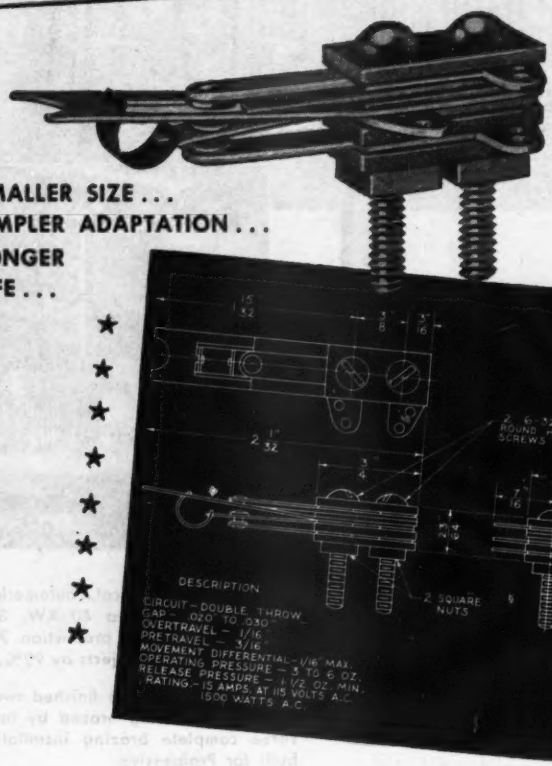
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PRETRAVEL – 3/16
MOVEMENT DIFFERENTIAL – 1/16 MAX.
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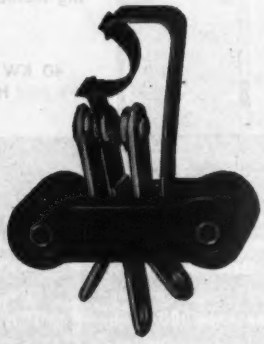

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traverse the fluid of the light valve they diffract the light beam. It will be recognized that it will take each part of the compression wave, corresponding to each picture element, a finite time to travel the length of the valve, thereby obtaining optical storage.

To counteract the movement of the modulation across the valve, which would result in the picture element traveling across the screen, a high-speed scanning wheel is introduced. A slow-speed scanning wheel directs each successive line of the frame to its place on the screen. This system has been in commercial operation in England in a number of theaters with great popular success.

Skiatron

The second system replaces the fluid valve and scanning wheels with a Skiatron vacuum tube shown in Fig. 2. Light is passed through a crystal of the type displaying electron-opacity, such as potassium-chloride. This crystal is in an electrostatic field, and is scanned by the electron beam from the gun. The beam intensity and motion are controlled as in cathode-ray projection tubes.

As the transparent positive ions of the crystal (potassium in the case of potassium chloride) are

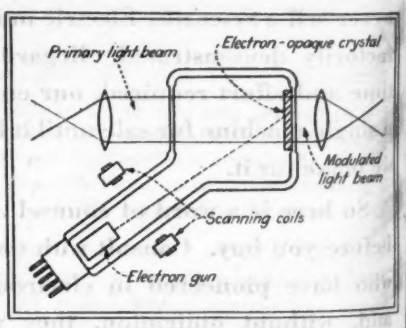

FIG. 2—The Skiatron, instead of using the cathode-ray beam to produce light for projection, uses the electron beam to control the opacity of the crystal, thereby modulating the primary light beam as does the standard motion-picture film

bombarded by electrons from the beam, they become opaque atoms. In this way the light beam is modulated.

It takes a finite time, dependent upon such factors as strength of the electrostatic field and crystal

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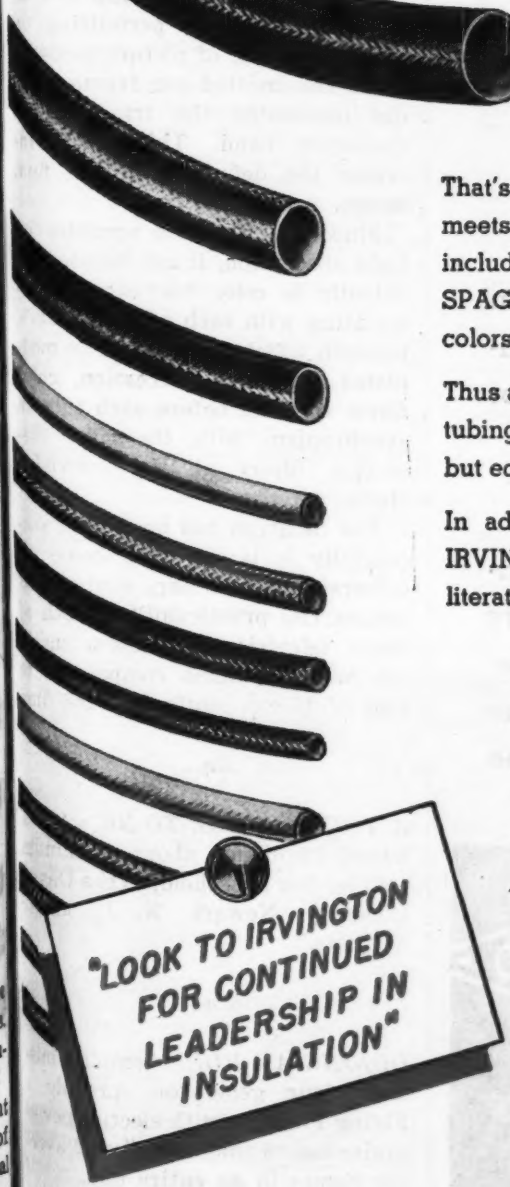

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history, for the loosely bound electron to abandon the atom and leave it again a transparent ion. The electron travels to the positive electrode used to produce the electrostatic field. In traveling from the atom to which it was originally directed, the electron successively neutralizes adjacent positive ions. In this manner, optical storage of the individual picture elements is obtained.

Using the Skiatron, the entire picture can be projected all the time; the time required for the electron to leave the electron-opaque crystal just coincides with the length of time required to scan the complete picture. Because of this melting of one frame into the next, there is a minimum of flicker. The number of frames that need be transmitted per second can be reduced, thereby permitting a greater number of picture elements to be transmitted per frame without increasing the transmission-frequency band. This would increase the definition of the final image.

Since the Skiatron operates on light absorption, it can be used efficiently in color television by associating with each of three tubes, through which the light to be modulated passes in succession, color filters rotating before each tube in synchronism with the color dissection filters at the television studio.

The Skiatron has been used successfully in large-screen home receivers for preliminary study of its commercial practicability. Both of these television projection methods have a gamma comparable to that of 16-mm motion-picture film.

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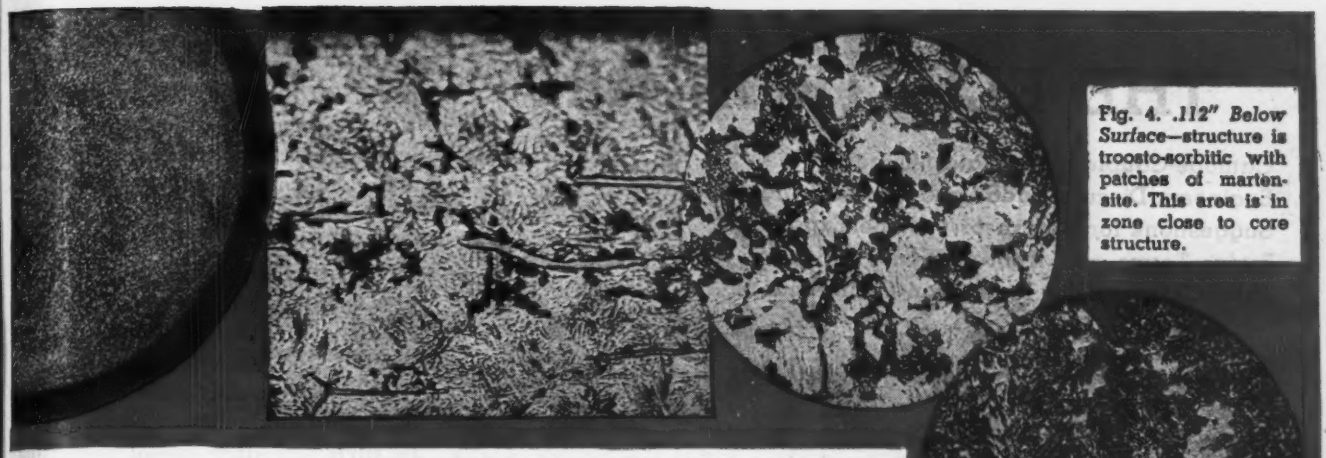

Fig. 4. *.112" Below Surface*—structure is troosto-sorbitic with patches of martensite. This area is in zone close to core structure.

Fig. 1. *Macrostructure*—Dark circumferential area is the hardened portion of the steel.

Fig. 2. *Surface of Shaft*—Medium-coarse grained martensite; dark areas of troostite. Manganese sulfide stringers.

Fig. 3. *.060" Below Surface*—light areas of medium-coarse grained martensite and dark areas of troostite.

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● Slow rotation of shaft during heating and quenching develops highest uniformity consistent with chemistry of the steel.

● Heating is so rapid and the time at heat so short that even normal grain growth associated with conventional heat treating methods does not take place. This makes it possible to use ordinary carbon steels in many applications where alloys heretofore have been required.

● High frequency induction heating develops a super-hard skin which provides superior wearing qualities.

● The speed of heating and the short time at heat prevents surface decarburization and scaling. Ground shafting and tubing may be hardened without the need for finishing after quenching.

● Due to the short heating and quenching cycle, the core structure is unchanged and highest ductility is maintained.

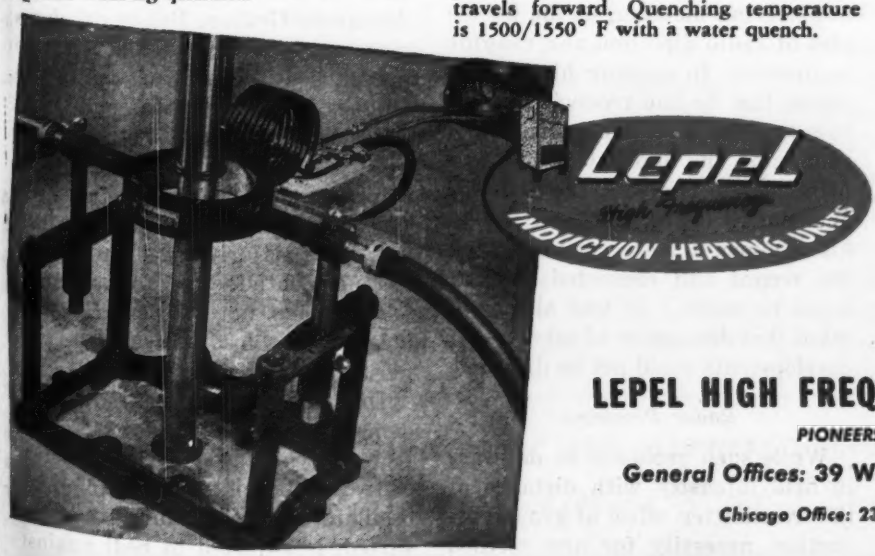
● Depth of hardness can readily be controlled by adjusting the input power or varying the travel speed of the part through the heating coils.

● Distortion is minimized, regardless of the length of the part.

Any hardenable steel can be heat treated with equal assurance of satisfaction. The photomicrographs illustrate the results obtained with a steel of the following analysis:

Carbon	.35/.45
Manganese	1.35/1.65
Phosphorus	.045 max.
Sulphur	.20/.30

In the illustration below, a 2" shaft 17" long is being hardened by passing it progressively through the heating coil and quench ring. Horizontal travel is 2½ feet per minute and the shaft is rotated as it travels forward. Quenching temperature is 1500/1550° F with a water quench.



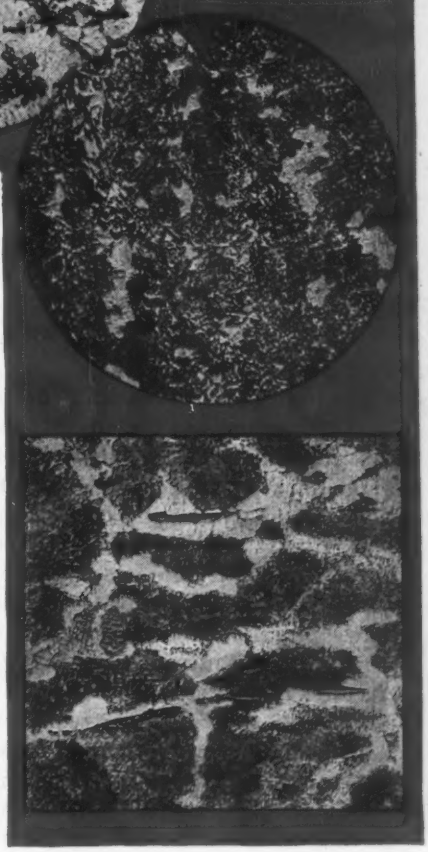


Fig. 5. *Core Structure* — medium-coarse grains of pearlite, lamellar pearlite and ferrite. Manganese sulfide stringers are uniformly distributed throughout. Structure is unchanged by hardening operation.

Fig. 1 shows the macroetched section of the shaft at approximately 1.5X magnification, indicating a penetration of 5/64". Only the surface yields the full hardness, Rockwell C60/C61, the Rockwell reading declining to C40 as the core is approached.

Figures 2, 3, 4 and 5 (500X magnification) show the grain structure at the surface, .060" and .112" below the surface and at the core respectively.

The same Lepel Unit can also be used for localized hardening, stress relieving, normalizing, brazing and soldering.

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THE ELECTRON ART

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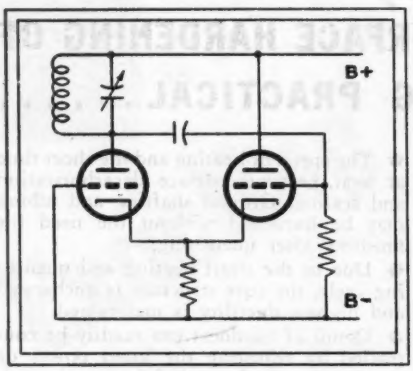
Cathode-Coupled Oscillator Circuit

CATHODE-COUPLED oscillators have advantages of stability and small loading of the tuned circuit. Several circuits and equations for their operation are given by F. Butler in the November, 1944 issue of *Wireless Engineer* (Dorset House, Stamford St., London S.E. 1).

The basic oscillator circuit, shown in the diagram, has the advantages that the tank coil is not tapped, the high input impedance of the cathode-follower stage on the right imposes light loading on the tuned circuit, and unity gain in the cathode-coupling stage provides ample drive for reliable oscillations up to very high frequencies for low Q circuits. This circuit can be further stabilized for single-frequency operation by using individual cathode resistors and coupling the cathodes through a crystal. This connection, by operating the crystal at series resonance, reduces the capacitive shunting of the crystal by its holder.

If the feedback circuit from the tuned circuit to the grid of the cathode-coupling stage is opened and an external signal fed to this grid, the circuit provides a highly selective amplifier with a high input impedance. The off-resonance attenuation is greater than for conventional amplifiers and may be increased by tuned output circuits in place of the load resistances.



The circuit of a cathode-coupled oscillator. Convenience in band-switching is provided by the two-terminal inductance

Engineers Discuss Radar and Surgical Metal Locator

TWO TECHNICAL PAPERS dealing with the role of electronics as locating devices were presented at the March meeting of the Chicago Section of the Institute of Radio Engineers at which Dr. W. E. Gilson, School of Medicine, University of Wisconsin, Madison, Wisconsin, spoke on "A New Surgeon's Metal Locator", and Dr. W. L. Everitt, Head of the Department of Electrical Engineering at the University of Illinois, and now in the Office of the Chief Signal Officer, Washington, spoke on "Recent Wartime Developments In Electronics" and outlined general principles of radar.

Dr. Everitt's talk represented one of the first discussions, in an open engineering meeting, of the principles of radio direction and ranging equipment. In opening his talk, he stated that he had received permission to discuss certain principles of radar and the application of these principles to two sets, the SCR-268 and the SCR-270, but stated that his comments were completely off the record and requested that no notes be taken. It was also indicated that discussion of other radar developments could not be divulged.

Radar Problems

While such problems as decrease in field intensity with distance of the transmitter, effect of ground reflection, necessity for new method of rating tubes in terms of peak power rating, factors for consideration in locating radar equipment, and factors to consider in the design and construction of directive v-h-f antenna systems were all discussed, it must be admitted that the topics discussed were such as to give no comfort and aid to the enemy. In fact, all of the radar principles discussed by Dr. Everitt were either already known to qualified radio engineers or could easily be surmised after casual reflection on the requirements of radar transmissions.

New to many of the engineers were the photographic slides of the two Signal Corps installations. Most important of all, however, was the fact that Dr. Everitt's lectures (which were also given before other sections of the IRE in the Mid-West) are the first time that this all-important subject has been discussed in an open engineering meeting. It would appear that such a talk is highly desirable in view of the comparative freedom from censorship in Great Britain and the fact that none of the developments under discussion had taken place since the entry of this country into the war.

Bullet Locator

Dr. W. E. Gilson, of the University of Wisconsin, gave a brief outline of various methods which had been used in the past half-century for locating metallic objects imbedded in the human body. Early work in that field was inspired by the assassination of President Garfield on July 2, 1881, which led Alexander Graham Bell to develop a system of locating bullets in the human body by making use of the Hughes balance. It was only after the employment of electron tubes in such applications that metal locators became smaller in size, effective, and practical for medical use. The majority of such locators are quite satisfactory for magnetic material but not particularly suitable for the location of non-magnetic material.

Dr. Gilson described and later demonstrated a locator of metal objects making use of the principle of two beat oscillators. One of these oscillators, whose tuning may be varied, is adjusted to beat against

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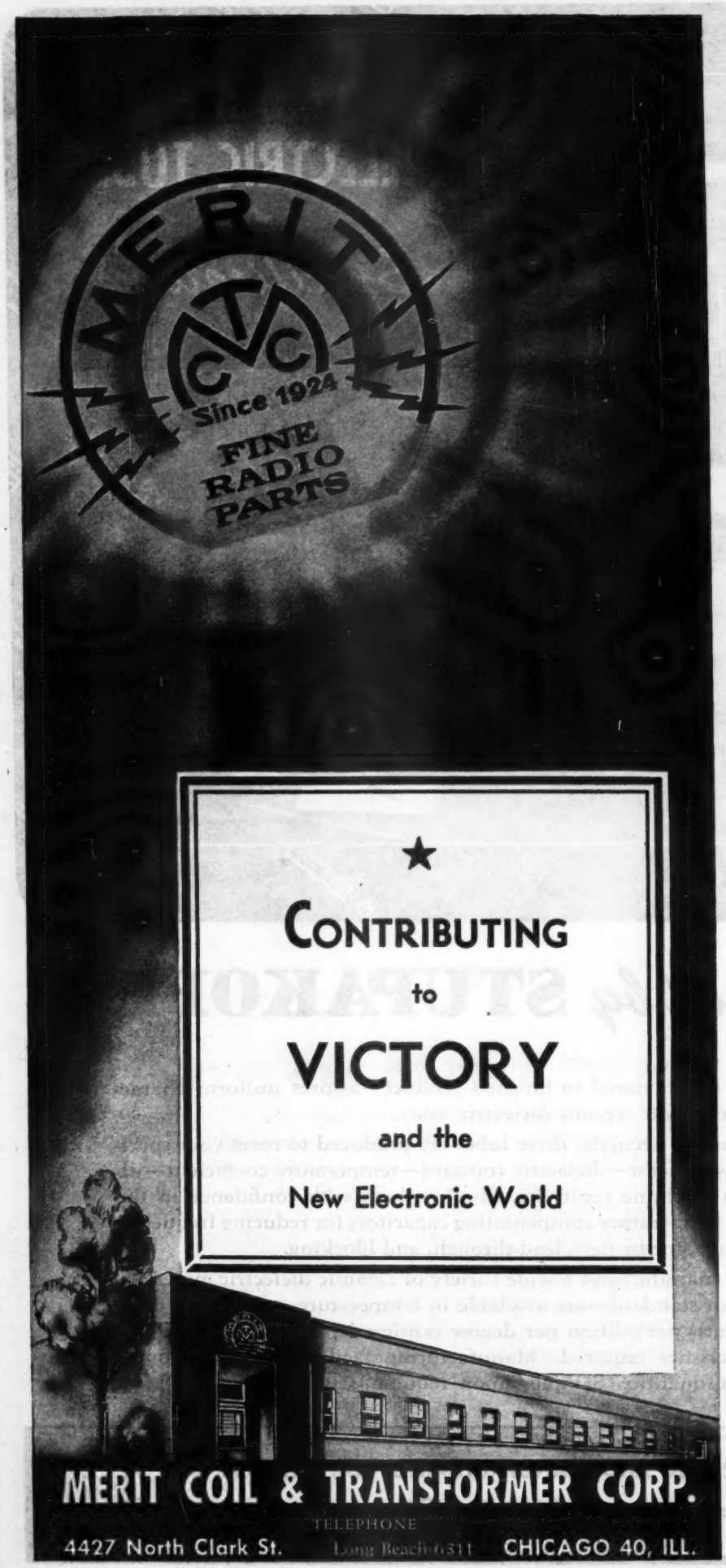

zero sound level between them, and the studio amplifier gain control setting would be determined by these peaks.

If the entire orchestra played, the timpani sound peaks would still be the highest instantaneous sound levels and the maximum readings on the volume indicator would be no greater than when the solo drum was played, even though the average sound power would be far greater. Thus, the average sound power in many cases may vary greatly without the studio engineer having to compress it at all.

Effect in Different Locations

In some situations, the use of expander amplifiers is not at all desirable, especially if the loud speaker is located in a room which has a high noise level and little sound-absorbing material. The best example of this is the average motion-picture projection booth where the normal volume range in the picture (without benefit of expansion) is usually too great for

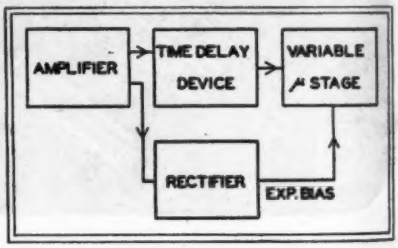

Fig. 1—Block diagram of automatic volume expander which anticipates changes in signal level and increases the amplifier gain before the peak passes through

the operator's comfort, the soft passages being drowned out by the projector noise and the loudest portions being re-flected and re-reflected by the hard walls until they are almost deafening. This would not be true in the theater auditorium, but in the reproduction of music in a factory or a railroad station similar conditions obtain and expansion should not be used. Even the typical city apartment has a high noise level, especially in the summer, and although it may have a fair amount of drapes and carpets, "enhanced" fortissimo passages drifting out the windows will not be greatly appreciated by the neighbors.

Another point that must be con-

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CEREX X-214	0.0066	235	0.30	70 sec.	hard-tough
LUSTRON	0.0007	168-176	0.05	120 sec.	hard-strong
RESINOX 7934	0.0361	255	0.030	6 sec.	hard-rigid
RESIMENE 803-A	0.2820	300	0.51	125 sec.	hard-tough
THALID X-526S	0.078	160	0.20	125 sec.	hard-tough

. . . completely reactive thermosetting resin for impression molding. Impregnates glass cloth, other fabrics or paper to make large, rigid panels or fully integrated forms of high strength. Ideal for housings, chassis or structural parts of electronic equipment. (Send for descriptive bulletin.)

**Standard ASTM tests are not applicable to these products. D495-42 tests give values ranging from 4-120 sec.*

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An abbreviated performance chart of seven Monsanto plastics used most today in electronics appears herewith. For complete information on these or other Monsanto plastics, or for expert assistance in adapting plastics to your electronic problem, write, wire, or phone: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts.

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sidered in using these circuits is the limitations of the equipment associated with the expander, for if this amplifier system does not have a dynamic range of at least 70 db (from noise level to overload point) expansion cannot be used to its full capabilities.

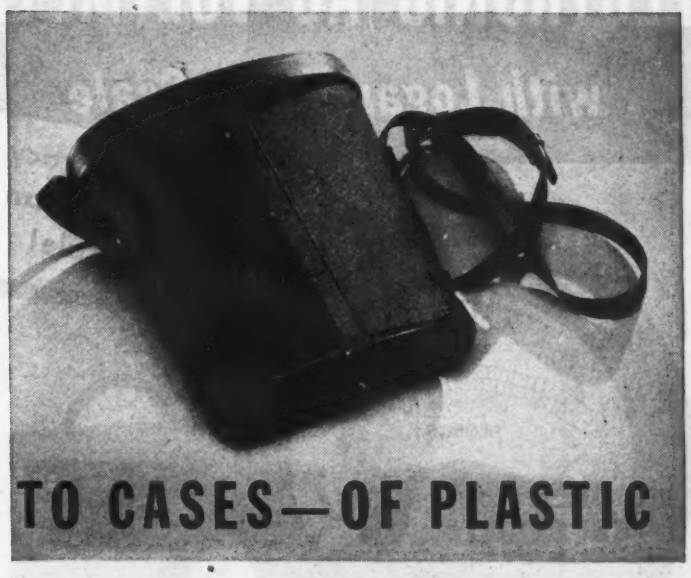
Time Lag

As to the defects of expander circuits, two might be noted. First, is the fact that expanders cannot anticipate changes in volume but rather have a slight time lag which makes it impossible for them to do more than approximate the original volume pattern. This lag is not important when volume changes are gradual, but on a sudden clash of symbols, for instance, the amplifier gain will not increase until after the sound peak has passed. This could be overcome by use of some sort of a time-delay device, perhaps a magnetic tape recorder, in a circuit such as Fig. 1 (which is otherwise a typical expansion circuit), the delay being adjusted so that the signal entering the variable-μ stage lags a little behind the bias variations. In this way, a sudden peak would increase the amplifier gain before the peak passed through rather than afterwards. The same idea could be used for compression where it should give better results than manual monitoring as it anticipates all changes in signal level.

Need for Balance

The second shortcoming of automatic volume expansion is that even if the circuit can foresee changes in volume it can never duplicate the original volume range because it has no way of knowing what these original levels were; that is, it will make the loud portions louder and the soft portions softer, but always by the same amount for a given input level. Thus the expander circuit might increase every signal that is 10 db above the average volume level to 15 db above the average, but the level in the studio might have been far higher than this, or even lower.

With manual compression, it would be extremely difficult to devise a circuit to overcome this fault, especially since most studio engineers ride gain on each microphone



LET'S GET DOWN TO CASES—OF PLASTIC

● *Typical of the ingenuity of American industry in developing new products and improving old ones with plastics is the above-illustrated plastic binocular case which was produced by the Hood Rubber Company for Bausch & Lomb Optical Company.*

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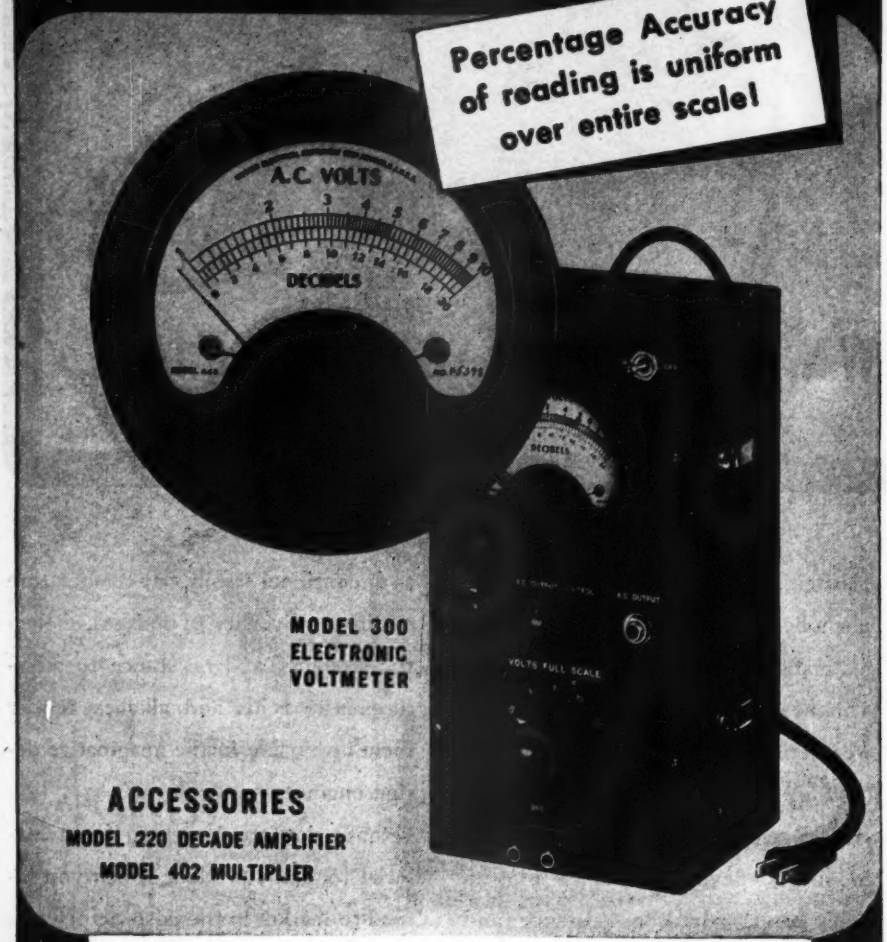

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Write for technical Bulletin 8

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separately, rather than use the master gain control; however, with automatic compression the amount of compression can be measured and an extra signal transmitted or recorded whose amplitude varies with the amount of compression and this signal can be used in the receiver or phono amplifier to regulate the amount of expansion.

Suggested System

Figure 2 is a schematic diagram of how such a system might operate. The compressor circuit is similar to Fig. 1, but in addition the compression bias is used to control

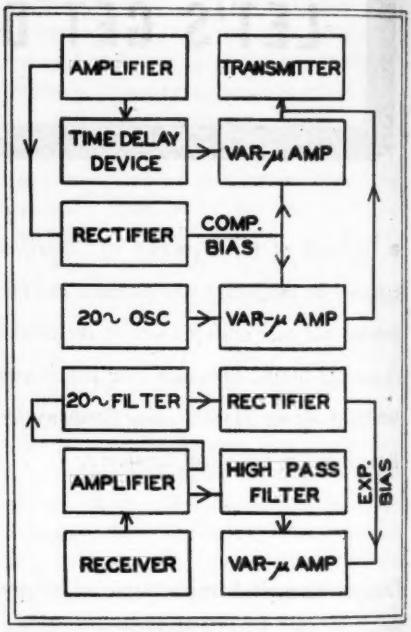

Fig. 2—Suggested system of volume expansion for a transmitter which employs a 20-cycle pilot signal whose amplitude varies with the amount of compression

the amplitude of a sine-wave signal whose frequency is just out of the audio range, for instance 20 cycles. This signal is then mixed with the regular signal and both are transmitted. In the receiver, the 20-cycle component is separated by a filter system and is rectified to furnish a volume-expansion bias. With careful design, an arrangement like this could give almost perfect volume-range reproduction.

Thus it may be said that although volume expansion is ordinarily desirable it is not as vital as might be expected, and in many installations would subtract from rather than add to the listener's enjoyment. In addition, the usual ex-

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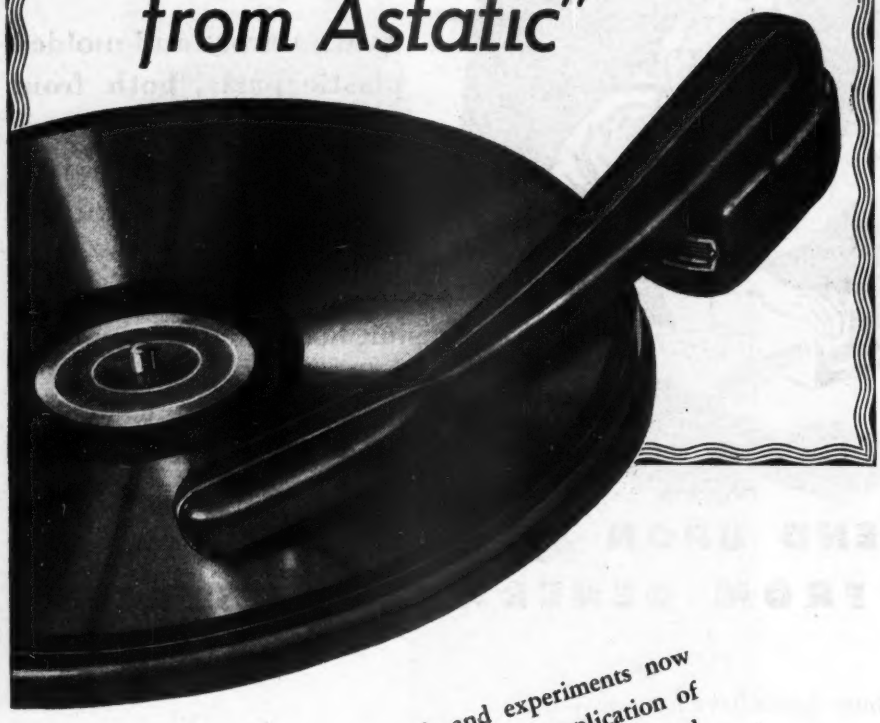

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pansion circuits will only roughly approximate the original volume pattern, an exact reproduction requiring a coördinated compression-expansion system.

• • •

Radar Terms and Abbreviations

FOLLOWING IS a list of the popular terms used by radar technicians as reported in *Aviation News* for April 2, 1945.

"A" Scope—An "A" scope indicates the range of the target as the distance along a horizontal line from the transmitted pulse to the signal (see Indicator)

AI—Short for Aircraft Interception. Short range airborne radar sets which guide nightfighers in their interception of enemy aircraft

ASV—Abbreviation for Air to Surface Vessel. ASV search sets are used in aircraft for detecting objects on the surface of the sea

AW—Aircraft Warning. AWS—Aircraft Warning Service

"B" Scope—A "B" scope shows the range vertically, and the relative azimuth or bearing horizontally. Signals appear as bright spots

Blip—British for pip. Term used to designate the signal on a scope or indicator

Blister—The housing for radar antenna (see Radome)

BTO—Bombing through overcast (e.g., with the "Mickey" set)

Chaff—Foil and paper strips dropped from airplanes to create false signals on enemy radar sets (see Window)

GCA—Ground Control Approach. The technique and/or apparatus for "talking down" an aircraft into approach for landing in poor visibility

GCI—Ground (or ship) Control of Interception. GCI stations vector (i.e., supply bearings to) to within visual or radar range of enemy aircraft

GL—Gun Laying. Range, bearing and elevation provided by GL equipment to direct ground or shipboard guns and control their fire

IFF—Identification of Friend or Foe. Method of automatically challenging and receiving posi-

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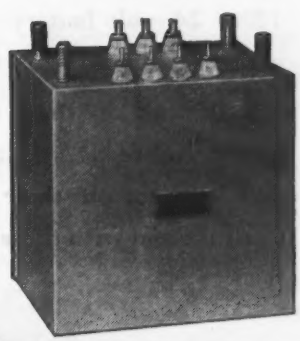

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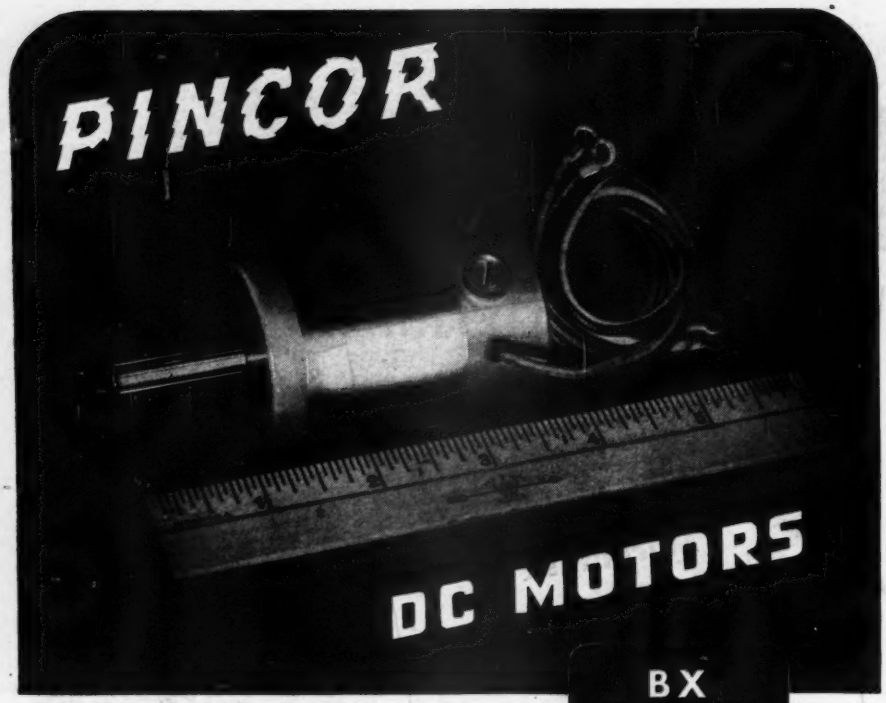

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tive response from aircraft or ship

Indicator — Radar signals displayed on face of a cathode-ray tube, the end of which is called the "scope" (from oscilloscope), or screen

Jamming—Introduction of false radiation into enemy radio and radar devices

Mickey—Radar set used by Pathfinder planes in BTO

Pip—American for "blip." Signal on scope

PPI—Plan Position Indicator, a circular map-type scope. May be compared with charts as a navigational aid. PPI scope photos have appeared in the press

Racon—Radar beacon, used as a navigation aid, "blind" landing of planes, etc. **Radome,** antenna housing (see Blister)

RDF—Radio Direction Finding, also Radiolocation. British terms for Radar (radio-detection-and-ranging), which is an American term

Window — Mechanical reflecting devices dropped from planes to confuse enemy radar

• • •

Third Chicago War Production Conference

IN AN ALL-DAY PROGRAM attended by more than 2,000 persons, the third Chicago War Production Conference was held on March 29, at the Stevens Hotel in Chicago. Thirty-six panels on a wide variety of technical topics were presented including radiography, x-ray applications, instrumentation, electronic control, and a general session on electronics.

Dr. L. T. Rader, director of the Department of Electrical Engineering at the Illinois Institute of Technology, spoke on "Motor and Industrial Process Control", pointing out that industrial electronic equipment must be designed and constructed on a different basis from that of communication equipment. Long life, dependability of operation under adverse conditions, and cost are important factors in the construction of industrial electronic devices. It was also pointed out that industrial electronics as such does not and probably will not stand on its own feet, but rather must be re-

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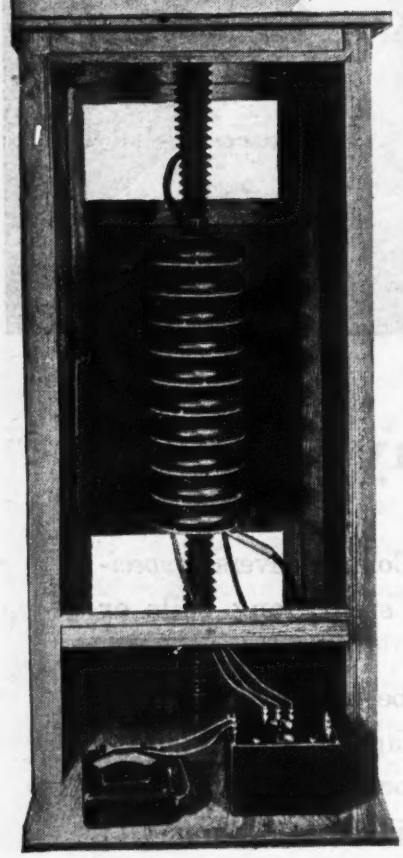

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WRITE FOR BULLETIN

Bulletin "F", recently released, includes detailed descriptions of standard Kilovoltmeters, Kilovoltmeter Multipliers, and Corona Protected Resistors and serves as a guide to the many special types that can be produced to match particular requirements in a range of potentials from 1 to 200 kilovolts.

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garded as a very important element in a completely integrated field of engineering. It was also pointed out that electrical components such as are used in the communication field are often too fragile for use in industrial equipment, and that in many cases a failure to provide sufficiently generous tolerances in engineering design also contributed to failure of the equipment in the field.

Electronic Heating

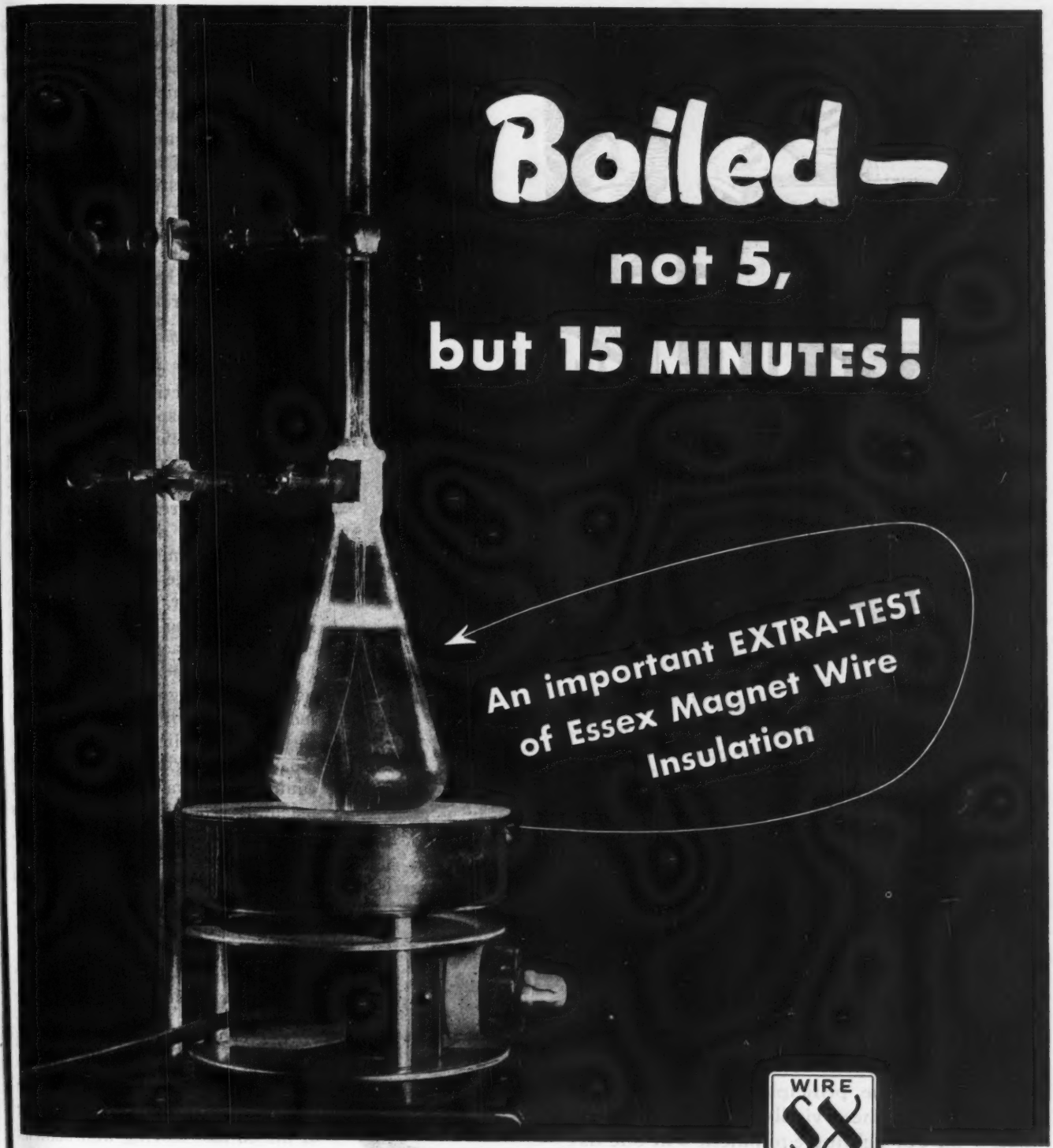
A talk on "High Frequency Induction Heating" was given by Mr. John M. Cage, engineer in charge of Electronic Control Division of Allis-Chalmers. The manner in which heat is generated in conducting materials, whether magnetic or not, was discussed and it was shown that the basic circuits of electronic heating units are all similar but that the number of applications is exceedingly varied. It was shown that the fundamentals of induction heating depend on: (1) induced voltage, (2) skin effect, and (3) hysteresis.

Carl Madsen, electronic engineer, Industry Engineering Department of Westinghouse, spoke on "High Frequency Heating of Dielectrics." Its use in the rayon and nylon industries, to set the thread to prevent twisting and stiffness of the yarn, was compared to the annealing process in metals.

He pointed out that the cost of sterilizing grain by electronic means is about 2 cents per bushel and that this cost was too high for this application. At the same time, the cost was sufficiently low that it could be applied to package goods.

Regarding food, Mr. Madsen commented on reports that it would be possible to cook meals by means of dielectric heating in the postwar period. This did not prove too attractive because it has not been found feasible to heat uniformly, since the fatty and lean portions heat at different rates. Moreover, in order to cook a 1-lb steak in 10 seconds, as has been held to be feasible, 150 kw of power would be required. Mr. Madsen did not state where or how the steak was to be obtained.

In the discussion following the panel on electronic controls, Dr. Rader pointed out that economic problems were of considerable im-



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portance in industrial applications. It was his observation that many parts going into industrial equipment are not well designed or are sometimes misapplied in practice. The practice of applying electronic control to existing equipment he viewed unfavorably and he anticipates that rotating equipment, for example, will be redesigned in the future so as to be more suitable for electronic control.

Efficiency

Considerable discussion was devoted to induction and dielectric heating. In response to a question as to the efficiency of electronic heating units, Mr. Cage pointed out that the efficiency as given by various manufacturers is measured in different ways and usually refers to the maximum possible efficiency under desirable operating conditions. However, this maximum efficiency is not too important since it can seldom be achieved in practice. Moreover, the cost of power is not generally a significant matter in most fields in which electronic heating can be applied successfully. As a basis for judging the operation of equipment, it was felt that rotating machines could be considered as having an efficiency of 75 percent, mercury-vapor inverters 90 percent, sparkgap generators 50 to 70 percent, and vacuum-tube oscillators 50 to 75 percent as approximate values.

Mr. Madsen indicated that he believed commercial baking by electronic methods has possibilities although this problem is not yet solved and one of the major difficulties is that of providing a crust on the exterior of the bread. Heating of ink on fast-moving web belts did not appear too attractive an application for dielectric heating since this would require waves of frequencies of hundred of megacycles or else such high voltages that flash-over would probably occur. In general, it was stated that rods or wires less than ½ in. thick could not be easily treated by dielectric heating although much thinner sheets could be treated. As regards the size of equipment, Mr. Madsen stated that so far as he knew, a 150-kw unit was the largest that had been put into commercial service for dielectric heating whereas

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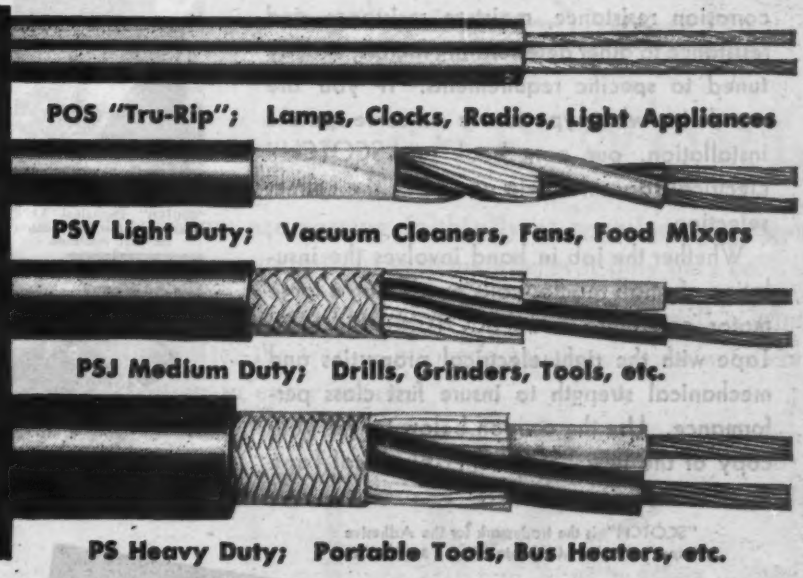

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Firm.....

Street.....City.....

Zone.....State.....Signed.....

Title

for induction heating, a unit of 1200 kw has been built. These values do not necessarily represent the largest installation since in several cases several units were used in parallel.

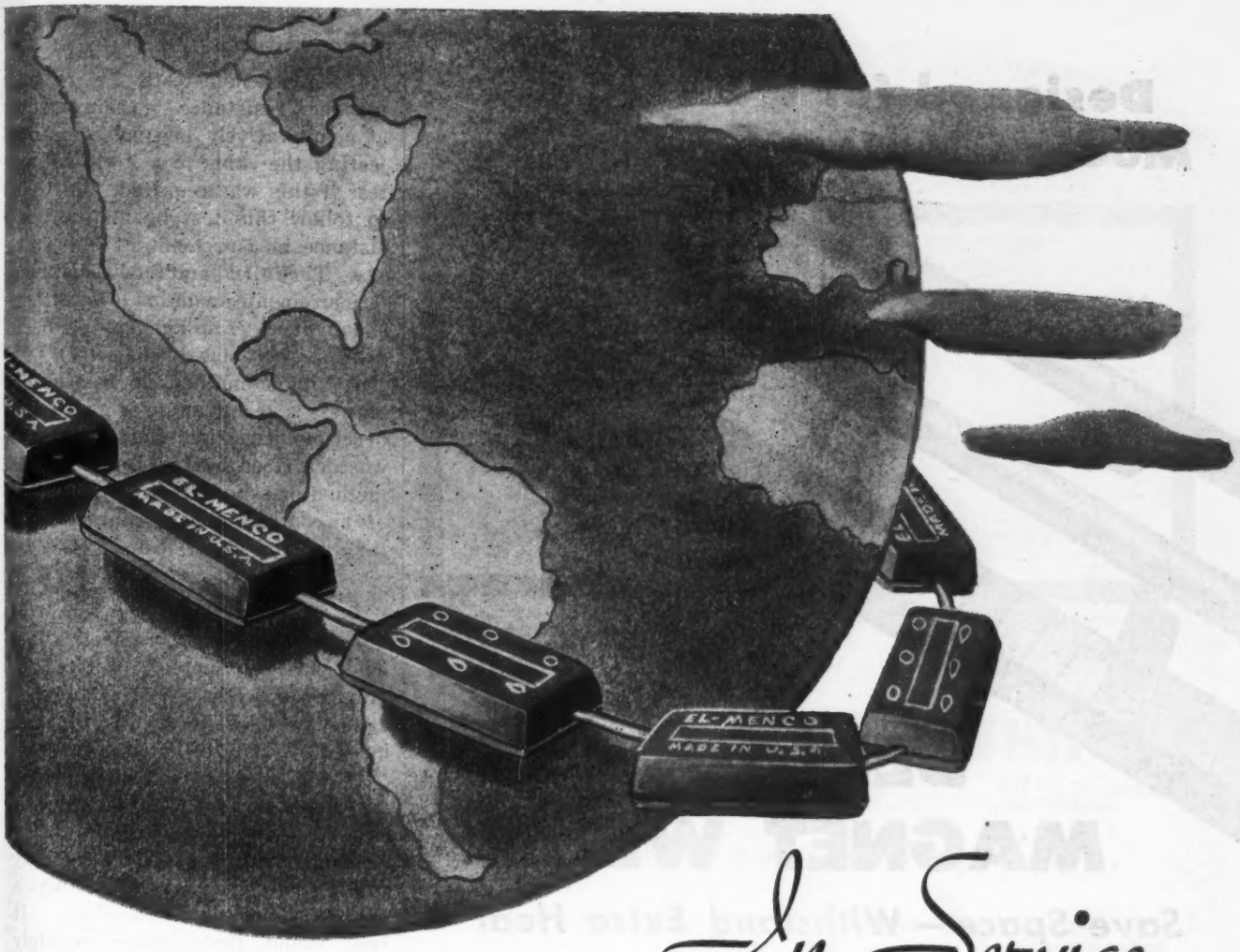
Special Problems

The question was asked whether it was possible to use dielectric heating in plastic molds where metal inserts were required. It was reported that by employing dielectric heating as a means of heating the pre-form, the plastic was made to form more readily in the molds and in this way could be used to reduce the difficulty.

As to the interference produced by electronic generating units, it was stated that efficient shielding of induction heating units and the relatively small field of these systems resulted in very little radio interference. Dielectric heating is most likely to produce greater interference because the output circuit was a more effective antenna. Mr. Madsen stated that in those cases where interference could not be suppressed by adequate shielding and filtering, consideration has been given to the operation of equipment on frequencies assigned by the FCC. Requests for frequencies of 13.6, 27.2 and 40 Mc for electronic heating have been submitted to the FCC.

Resistance Test Technique

The instrumentation panel was given over to measurements. J. F. Inman spoke on "High Voltage Insulation Testing", J. Dauber of the Acme Industrial Co. spoke on "Gaging Methods—Size, Angle and Flatness by Light Wave Methods" and D. O. Kochmich of the Trimount Instrument Co. spoke on "Static and Dynamic Pressure Measurements". Mr. Inman gave a historical review of high-voltage methods of measuring insulation resistance, pointing out that the calibration of resistance by means of current measurements (as in the usual ohmmeter) permits the calibration of very high resistances even though no standards are available. Measurements of resistance of cables subjected to high voltages frequently produce breakdown which is not always detected. To



In Service

AROUND THE WORLD

El-Menco Capacitors are serving faithfully at countless vital spots in Army and Navy communications systems wherever they may be.

Because of their recognized high quality we know they will continue to girdle the globe after the war — in products whose manufacturers will demand perfection in *every* detail.

Manufacturers of Electronic Equipment:

Send, on firm letterhead for new Capacitor Catalog

THE ELECTRO MOTIVE MFG. CO.
Willimantic, Conn.

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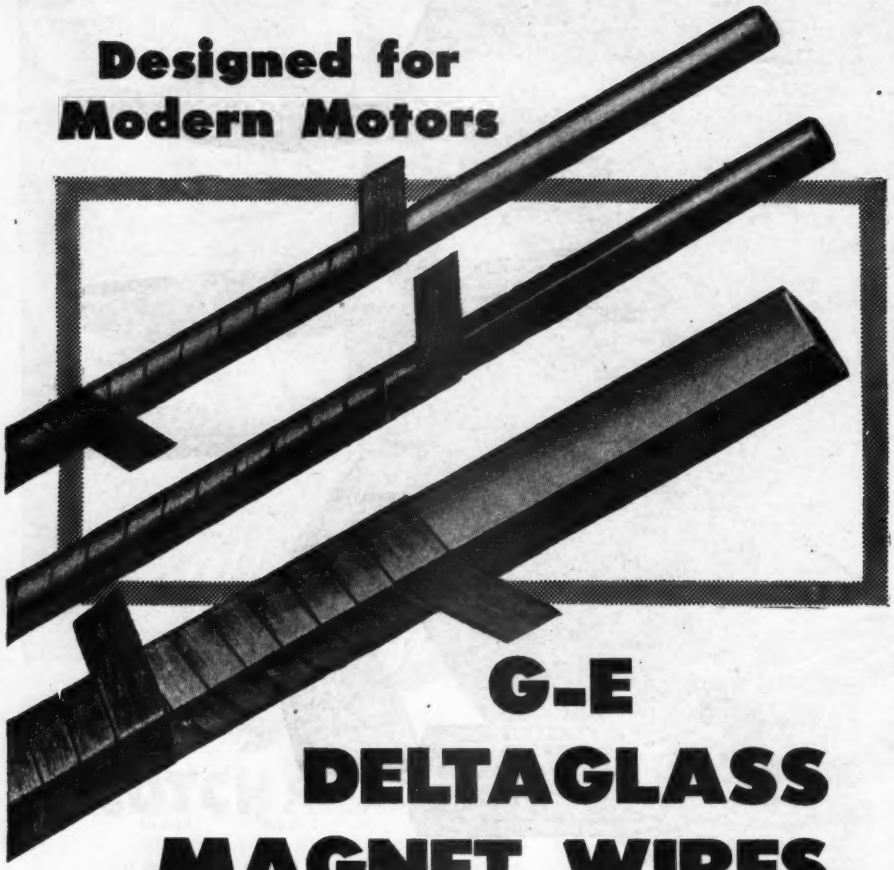
MOLDED MICA—
MICA TRIMMER

Capacitors

Designed for Modern Motors



G-E DELTAGLASS MAGNET WIRES

Save Space — Withstand Extra Heat

Space factor is becoming increasingly more important in the selection of magnet wire because modern motors are designed to give the same power from smaller frames. Designing engineers of electrical products specify G-E Deltaglass Magnet Wire because it permits a greater amount of copper in the space allowed for the winding — and will still withstand the extra heat by a comfortable margin.

Deltaglass Magnet Wires are used for winding motors, lifting magnets, brake coils, generators and in numerous other electrical devices and equipment. Deltaglass is insulated with yarn of spun glass that is firmly bonded to the copper conductors with a heat-resisting insulating varnish. It is constructed with either single or double wraps of glass yarn or with Formex copper conductors covered with single or double wraps of spun glass. Deltabeston is smooth, tough and extremely flexible. It can be flexed and bent into intricate shapes without rupturing its insulation. It's available in round, square and rectangular shapes in a full range of sizes.

Here's a catalog that will help solve your wiring problem. You can obtain your free copy by writing to Section Y-555-119, Appliance and Merchandise Dept., General Electric Co., Bridgeport, Conn. All Deltabeston Asbestos- Glass- and Synthetic-insulated Wires and Cables for special applications are distributed by Graybar Electric Co., G-E Supply Corp., and other G-E Merchandise Distributors.

BUY WAR BONDS AND KEEP THEM

GENERAL ELECTRIC

make insulation tests, he recommended resistance measurements at comparatively low voltage, subjecting the cable to a high-voltage test if this was required, and then to follow this test by another resistance measurement at low voltage. The initial and final resistance measurements made at low voltage should check if no damage has been done to the cable insulation.

A simple method of measuring flatness, size and angle of gages and precision parts in industrial plants was described by Mr. Dauber. The method has for its basis the use of an optical flat in contact with the material under test.

Spore Life

In speaking on "Tropicalization, The War on Spores", Wilfred F. Horner, Director of the Biological Lab., Belmont Radio Corp., discussed the work of his organization.

It was shown that the growth of fungus required the presence of water as a liquid, and oxygen, while essential nutrition was frequently provided by the material on which spores deposited themselves. It was found that spores multiply most rapidly at temperatures between 65 and 80 degrees and for values of pH between 6 and 7. Colored slides of spore growths and the effect of various fungicides were shown and several types of materials suitable as fungicides and for tropicalization were mentioned.

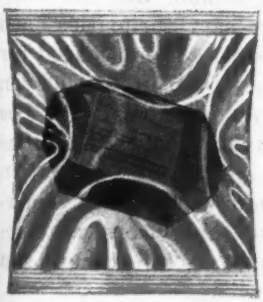
Leonard R. Robb, Production Control, Stewart Warner Corp., spoke on "Crash Program vs. Planned Production", outlining the difficulties that a manufacturer of electronic equipment faced during the war production schedule.

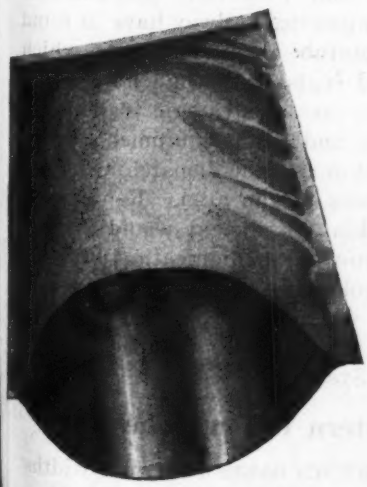
Raoul du Chatellier, Returned Communication Officer Military Intelligence Service, 1st Army A.E.F. and now with the Galvin Mfg. Co., in a restricted talk "What We Thought of FM in Normandy" outlined his experiences since landing in France last June. This talk served to outline some of the conditions under which communication equipment was operated, some of the difficulties in operation which were encountered in the field, and indicated the value of f-m equipment as compared to amplitude modulated equipment.

SNIP IT, SEAL IT, SHIP IT!

in Traco "All-Size" Bags

Tubular Form—1000 Foot Reels





Make quickly in your own plant TITE-SEAL Cellophane Bags of any size that seal out dust, air, water and moisture-vapor. They protect military supplies from damage in transport or storage.

Acceptable for Methods I and IA, type III packaging . . . available in 3, 4, 6 and 8 inch widths under proper priority . . . 1000 feet to the reel. Saves stocking large quantities of special-sized bags. (Stock Bags also available in above widths.)

"All-Size" Containers and custom made bags can be furnished plain or printed in any widths or lengths desired on special orders of sufficient quantity.

Heavy foil-lined laminated bags or tubes meet every requirement of Methods I, IA and II Military Packaging. LOXTITE Partitions give crash protection to fuses, rations, and delicate or fragile items.

Reasonably prompt shipment can be made on government orders bearing end use. A card will place our technicians at your command.

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For parts identification and many other uses. Saves time and trouble. Pressure sensitive. Available in small quantities. Prompt shipment.

NEWS OF THE INDUSTRY

Science and prosperity; postwar markets; microwave relay systems; television preview; radar avigational aids; meetings; FCC broadcast actions; business news

Radio-Radar Openings

ACTIVATION of an Army Air Forces development project to be known as Watson Laboratories, at Red Bank, N. J., has created approximately 325 openings for radio and radar engineers. Salaries range from $2600 to $5600 per annum.

Work to be done in this installation is on the development of ground communication systems peculiar to the AAF. The positions are under civil service and carry all the rights and privileges of a war service appointment under the Classification Act of 1923. More information may be had from the New York office of the Civil Service Commission or by direct inquiry to the personnel office of the laboratories.

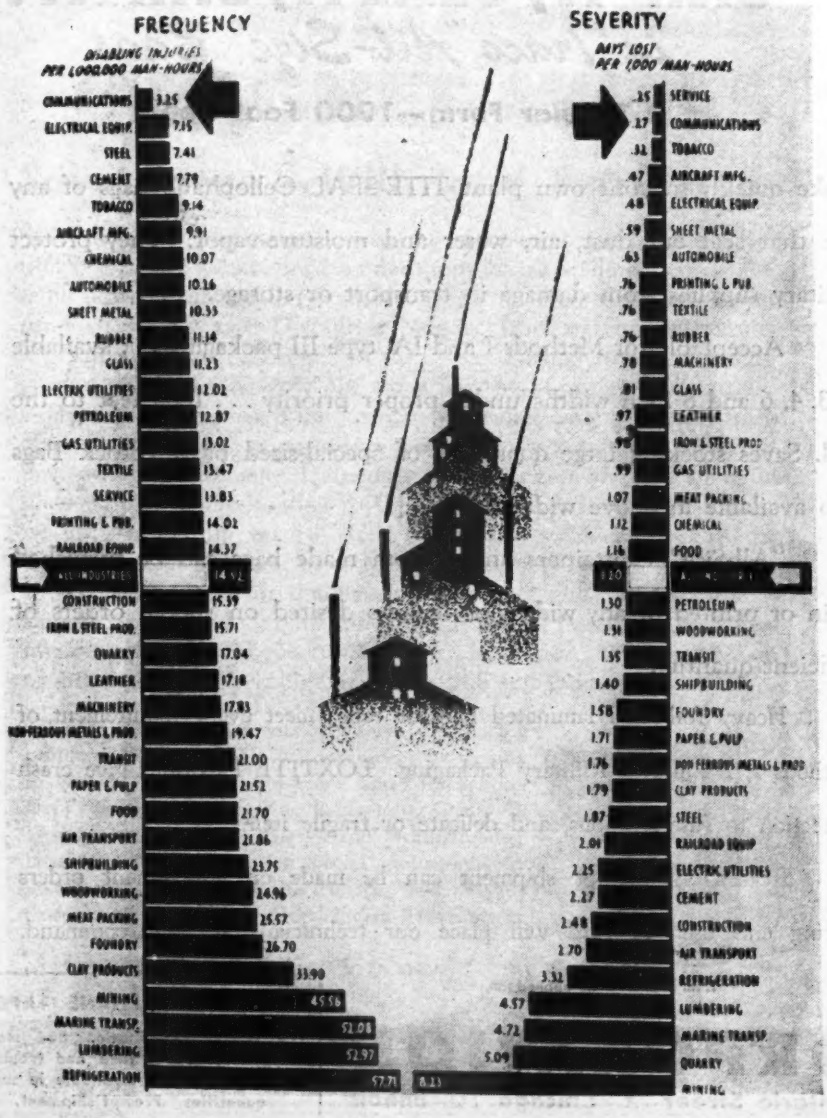
Science and Progress

OUR FUTURE advancement toward the necessary economy of abundance depends upon getting the greatest possible number of persons engaged in scientific pursuits, according to Samuel J. Novick, president of the Electronic Corp. of America.

Speaking recently at a New York Times Hall Forum in New York, he said that progress in science during the war is due to: (1) Every scientist who could contribute to the war effort being systematically sought out; (2) Huge expenditures for laboratory facilities and field work; (3) The war-imposed necessity for better organization and direction of research; (4) The fact that there was nothing to hold back new ideas; and (5) The natural incentive created by the vacuum of an unlimited market.

His suggestion was that we must maintain similar stimuli if we are to put our economy on an even keel after the war.

INJURY RATES FOR INDUSTRY—1943



From figures reported to National Safety Council

Street-Car Radio

FREQUENCY MODULATION radio equipment is planned for installation in major Pacific Coast war centers to speed the flow of street cars and buses, according to recent disclosures by transit officials in San Francisco, Oakland, and Los Angeles. Necessary priorities and FCC permits have been secured for the spending of about $40,000 on a two-way radio system in the Los Angeles Transit Lines. Facilities will include a 250-watt f-m station which communicates with emergency trucks, supervisors' automobiles, and many motor coaches and street cars as well.

In San Francisco, operators of the municipal railway have in mind a phototube recording device which would register the bunching up of street cars at strategic traffic locations, and radio equipment which would enable the dispatching of inspectors to the area. Repair and wrecking equipment would also be in two-way communication with the control tower. The entire installation would run to $50,000. Oakland plans similar facilities on the Key System.

Western Union Relay

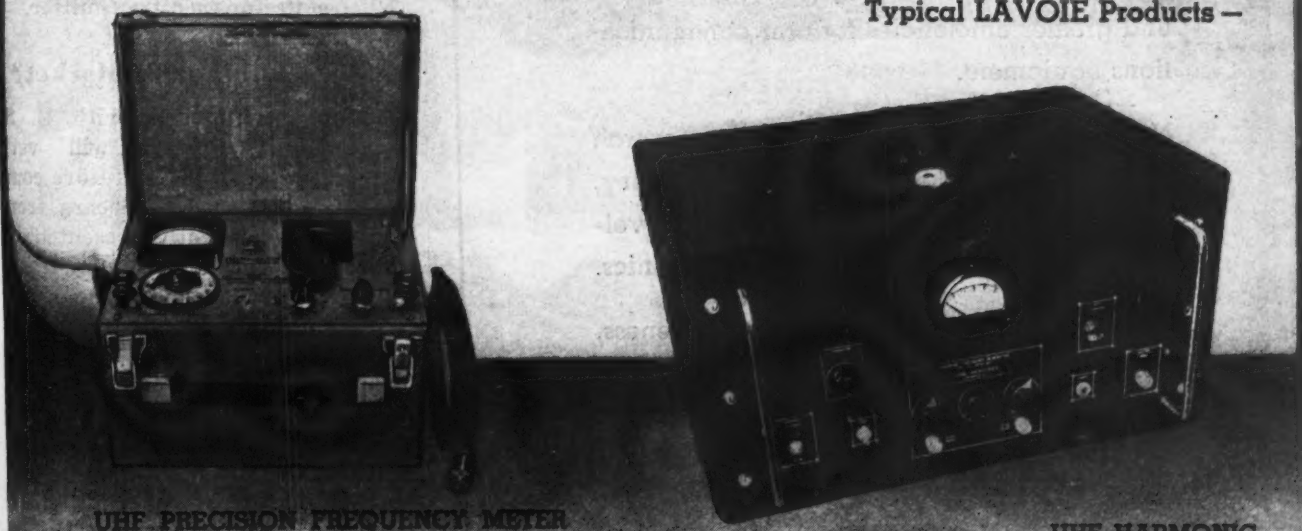
FREQUENCY BANDS of various widths between 2,000 and 11,372 Mc have been allotted by FCC to Western Union Telegraph Co. for experimentation regarding the practicality of transmitting regular telegraph

PROBLEMS *in the UHF Field?*

Your present or proposed product may demand precision in design, manufacture and performance. As specialists in the development of UHF equipment, we may be able to aid you in accomplishing this . . . at a lower cost. It's worth checking into. To help in the development of new products . . . or improve old ones, LAVOIE LABORATORIES offers this 3-point service:

1. **TECHNICAL ADVICE by thoroughly experienced UHF engineers who know the "how" and "why".**
2. **DESIGN – from the idea to the finished product, with a knack for practical, low-cost production.**
3. **MANUFACTURE of complete assemblies employing shop technique especially suited to UHF work.**

Typical LAVOIE Products –



UHF PRECISION FREQUENCY METER

Completely portable *Accuracy 0.1%*

Battery or AC-Operated

Models available from 100 to 2000 megacycles with 2 to 1 frequency coverage on each model.

RECOMMENDED FOR:

- *Production testing*
- *Measurement of oscillator drift*
- *Independent alignment of transmitters and receivers*
- *Precise measurements of frequencies*

UHF HARMONIC FREQUENCY GENERATOR

PROVIDES output voltages which are multiples of 10 or 40 megacycles with CRYSTAL-CONTROLLED accuracy.

SELECTS 10 or 40 megacycle series and IDENTIFIES one of these harmonics by means of a Frequency Identifier which consists of a filter providing high attenuation of all voltages except that of frequency to be identified.

USED FOR calibration of receivers, wavemeters, or using internal beat detector, for calibration of oscillators and signal generators.

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.

Specialists in The Development of UHF Equipment
and in The Manufacture of UHF Antennas

NEW SECRETS

In the Temple Laboratories, engineers and technicians toil unceasingly to provide new and greater efficiencies for war communications equipment.

Needless to say that out of this constant search for betterment comes further discovery, further knowledge — new secrets of development in the limitless field of electronics.

Temple engineering skill and inventiveness, fostered still further by the stress and strain of war, will contribute richly indeed to the electronic world of the future.

Temple

Electronics Division

TEMPLETONE

RADIO MFG. CORP.

New London, Conn.

service via radio relay. Test installations will be between New York and Philadelphia and two years' time has been authorized for construction.

A number of FCC regulations were waived in this case. For instance, regular commercial rates will be charged in order to create an exact parallel between wire and radio operation. Also, no call-letter transmission will be required.

Terminal stations will be located in the WU building in New York and in Camden, N. J., the latter station being remotely operated from Philadelphia. Two intermediate unattended repeater stations will be located in Bordentown and New Brunswick, N. J.

Maximum power at each station is to be 15 w and types of emission will include A0, A1 — A4, and special for multichannel telegraph, teleprinter, facsimile, and business machines. An RCA-developed modulation system will be used to get 32 circuits for each transmitter.

Future Equipment Market?

RUSSIAN FAMILIARITY with U. S. electronic equipment will very likely be a great aid in future commercial relations, it appears from information recently presented by Foreign Economic Administrator Leo T. Crowley before the House Foreign Affairs Committee.

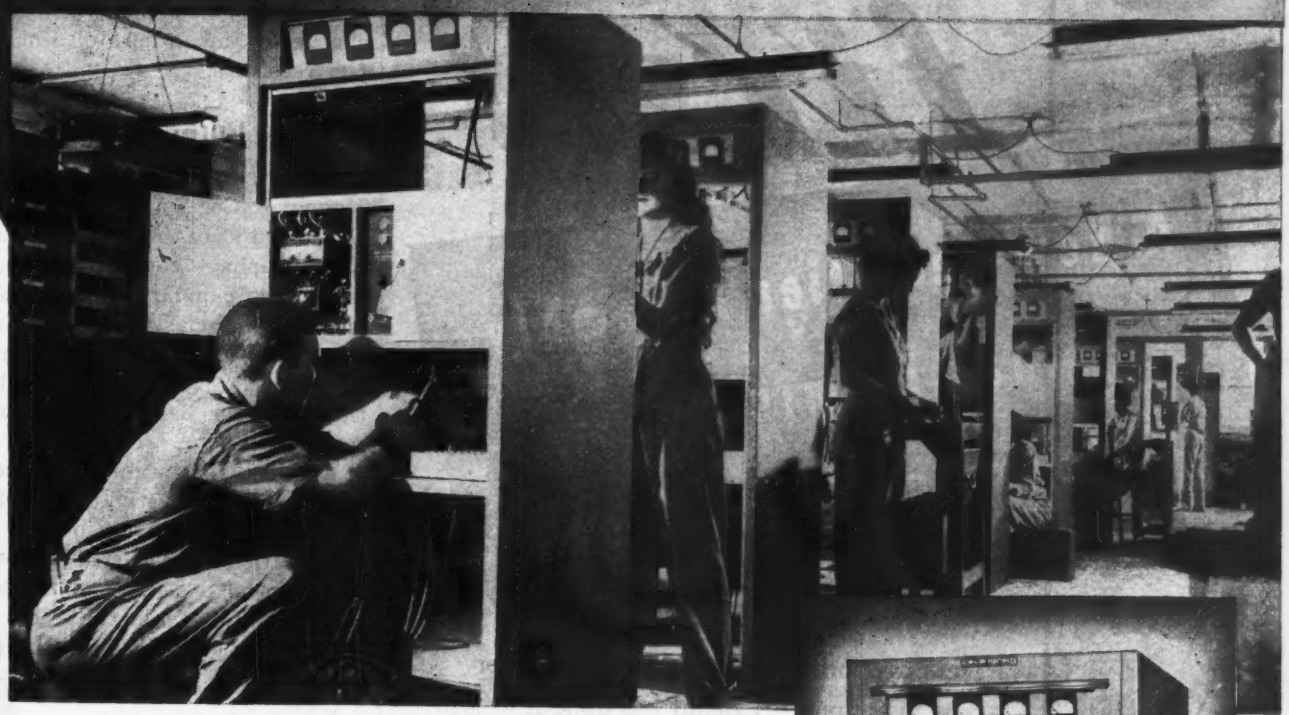
He pointed out that 12,000 airplanes sent there from the United States were all equipped with the latest radio and radar equipment. Other electronic gear found its way to Russia installed in 3,300 armored cars, 6,000 tanks, 5,500 prime movers and 1,700 ordnance service vehicles.

Adapters for F-M Sets

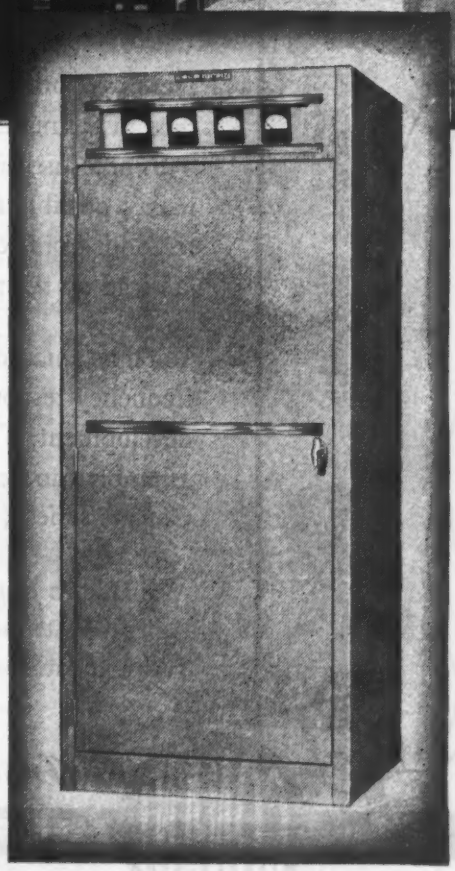
IN THE LIGHT of discussion revolving about the question of shifting f-m frequencies to the 84-102-Mc band, several manufacturers have come out with equipment described as suitable for adapting old receivers to the new conditions.

Besides a unit which was presented during recent hearings by members of the FCC staff and reported as having been built for $8.85 at retail prices of components, both Hallicrafters Inc., and Emerson Radio & Phonograph Corp. have

"Line Production" Experience IN RADIO MANUFACTURING



From Wilcox's war experience, as one of the largest manufacturers of radio communications equipment, has come many new products... a completely modern mass production factory... a trained engineering staff... plans and the knowledge needed for both war and peacetime products of highest quality. Look to Wilcox for leadership in radio communications equipment!



Model 50A Modulator — The 1600 watt 50A Modulator, shown at right, may be used for transmitter modulation, or high-powered audio needs.

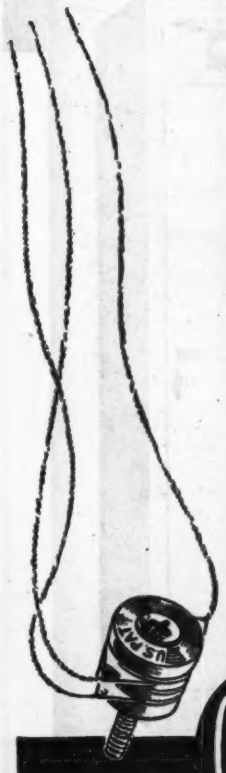
WILCOX ELECTRIC COMPANY, INC.

Manufacturers of Radio Equipment

FOURTEENTH AND CHESTNUT — KANSAS CITY, MISSOURI

Another Conant first!

A New Rectifier Assembly that Eliminates Temperature Variations



Here's important news for users of rectifier type instruments. Conant has done it again! This new instrument rectifier application makes possible for the first time complete freedom from temperature errors. AC values are read on the same linear scale as DC values.

You'll be amazed at the vastly improved frequency response achieved by this new development. This remarkable assembly can be furnished in any of three Conant series (500, 160 or 160-C).

Available to original purchasers of Conant Instrument Rectifiers *license free*. Write today for details.

CONANT *Instrument Rectifiers*

ELECTRICAL LABORATORIES

6500 O STREET, LINCOLN 5, NEBRASKA, U. S. A.

20 Vesey St., New York 7, New York
85 E. Gay St., Columbus, Ohio
600 S. Michigan Ave., Chicago 5, Ill.
1215 Harmon Pl., Minneapolis 3, Minn.
2017 Grand Ave., Kansas City 8, Mo.
1212 Camp St., Dallas 2, Texas
378 Boulevard N. E., Atlanta, Ga.
4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
Export Div., 89 Broad St., N. Y. 4, N. Y.
50 Yarmouth Rd., Toronto, Canada

announced readiness of units of their own design.

Hallicrafters referred to two types which are ready to produce—one priced at $5.60 and one at $11, both FOB Chicago to quantity buyers. The more expensive of the two uses three tubes.

Emerson Radio & Phonograph Corp. described their adapter as relatively simple and expressed willingness to supply it free of charge to any owners of Emerson f-m receivers.

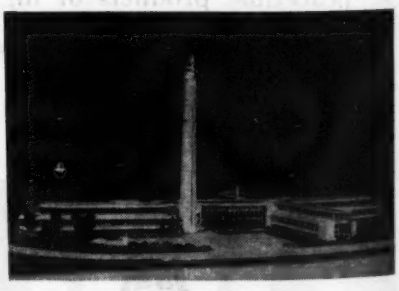
Fidelity Enthusiasts

AS DISCOVERED in a poll taken by the Magnavox Co., a full two-thirds of the owners of Magnavox radio-phonographs consider popular music less popular than symphony and the other classics. Probably as a result, 44.3 percent of the owners list superior tone as the feature they look for first in home sound equipment.

Another significant fact uncovered by the investigation is that the record-player section of the combination is reported to be in operation 43.3 percent of the total playing time, while the radio receiver only gets the nod 56.7 percent.

Laboratory Consolidation

ELECTRONIC SCIENTISTS of IT&T (International Telephone & Telegraph Corp.) in the U. S. and other countries are now grouped into a corporate unit—International Telecommunication Laboratories, headquarters of which will be in the Nutley, N. J. project illustrated.



Designer's-eye view of the projected International Telecommunication Laboratories headquarters in Nutley, N. J. One unit has already been started

Capitalized at $2 million, the new corporation is owned jointly by IT&T and a subsidiary, International Standard Electric Corp. President is E. M. Deloraine, gen-

For mobile two-way communication specify KAAR RADIOTELEPHONES

KAAR PTL-10X TRANSMITTER

10 WATTS • 1600-2900 KC*

The PTL-10X is a highly efficient medium-frequency mobile transmitter. It provides communication from a moving vehicle over distances ranging from 50 to 75 miles when used with AUTO-LOAD self-loading antenna.

The "Push-to-Talk" button on the microphone completely controls the transmitter, lighting the instant heating tubes, starting the power supply, automatically silencing the receiver, and switching the antenna to the transmitter. The standby current is zero.

Models for special applications are available, including the PTL-22X medium frequency transmitter with 22 watts output, and the PTS-22X, a 22 watt transmitter for operation in the 30-40 MC band.

KAAR AUTO-LOAD ANTENNA

This antenna, with matching coil in the base, is designed for use with the PTL-10X (or with similar medium frequency transmitting equipment) and matches the 72 ohm transmission line from the transmitter and receiver without auxiliary tuning equipment. It provides an efficient method of obtaining maximum signal strength at medium frequencies with a short antenna. It can be quickly installed on the rear bumper or on the side of any vehicle.

**Special ranges to 7000 KC available on special order*

KAAR 11X RECEIVER

6 TUBES • 1600-2900 KC*

The popular 11X receiver is a crystal controlled superheterodyne for mounting in an automobile or other vehicle. It contains a no-signal squelch circuit, and is designed for commercial, civil, and military applications.

This receiver offers remarkable accessibility. The top is removed by simply pushing aside two snap catches, or the entire receiver can be whisked out of the vehicle by releasing only four catches.

KAAR

ENGINEERING CO.

PALO ALTO, CALIFORNIA

Manufacturers of high grade mobile and central station RADIOTELEPHONE EQUIPMENT • POWER PACKS • CRYSTALS • VARIABLE CONDENSERS MICROPHONES • AUTO-LOAD ANTENNAS

Export Agents: FRAZAR & HANSEN, 301 Clay St. San Francisco 11, California, U.S.A.

Look to COMCO for VHF

Customized

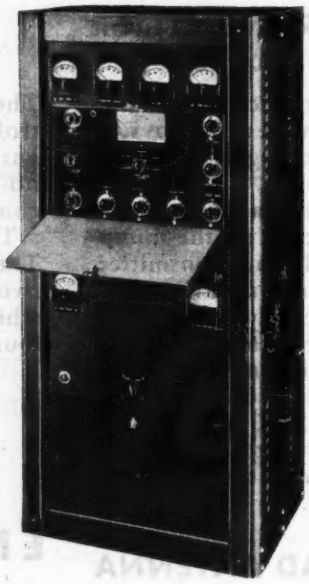
Radio and Electronic Equipment

Test-Proved for Dependable Performance

The Comco system of testing and inspection maintains a continuous and rigid control of quality. The finest scientific devices and instruments in the hands of experienced technicians insure positive protection against all usual causes of sub-standard performance. It is no accident that COMCO *customized* equipment has become widely known for unvarying quality and dependable performance.

COMCO VHF TRANSMITTER MODEL 170

Reliable VHF, 50 watts output. Frequency range 100 to 160 Mc. Cabinet size: Width 23"; depth 18"; height 48". COMCO Model 127AA Transmitter also available for operation on a frequency range of 200 to 550 kc.



COMCO VHF RECEIVER MODEL 132

Compact VHF crystal controlled, fixed frequency, superheterodyne. Single channel reception; 5¼-inch relay rack panel mounting. 12 tubes. Frequency range 100 to 160 Mc. Medium and low frequency receivers also available.

WRITE! *Just a note on your company letterhead outlining your exact requirements. We'll give you the benefit of our specialized experience. We can supply a wide variety of* customized *equipment on priority NOW. We are accepting non-priority orders for post-war delivery.*

MANUFACTURERS OF RADIO COMCO & ELECTRONIC EQUIPMENT

COMMUNICATIONS COMPANY, Inc.

CORAL GABLES 34, FLORIDA

E. M. Deloraine, president of International Telecommunication laboratories; Nutley, N. J., science headquarters of IT&T

eral director of Federal Telephone & Radio Laboratories. Vice-presidents include Harold H. Buttner and Douglas B. Baker.

Dedicated to initiating inventions, developing them, and providing an interchange of information among system laboratories in New York, London, and Paris, the new corporation will be located in a structure specially designed to meet the exacting requirements of electronic research. The first unit is presently under construction.

Democratic Design

POSTWAR MODELS of Bendix radios will be influenced in their design by results of tests currently being conducted by that company. Audio-frequency range preferences are determined by comparison between a prewar receiver and a new wide-range job. Both instruments are set at peak bass and treble range for the first part of the test and at equal volume levels. Later one selection is played with both controls reduced. Listeners, who range from farm workers and business executives to bobby-sock swingsters and symphony patrons, record their votes on special forms.

Further tests for Bendix will be used to make decisions on the styling of receiver exteriors. Opinion Research, Inc. will conduct, throughout the nation, style clinics which will simulate actual retail showroom buying conditions.

More Basic Science

ON THE THEORY that building new postwar industries and products for mass consumption will depend on the continued discovery of new scientific laws, Battelle Memorial Institute is planning an expanded program of research education. The program, which will be directed at the graduate level, is an expansion

ADVANTAGES OF THERMOPLASTIC

There are fourteen practical advantages of theremoplastic insulation over older types of construction . . . advantages which PLASTIC engineering now makes possible at what, in most cases, is NO PRICE PREMIUM. Check them yourself: 1. Superior aging properties, 2. High resistance to oxidation, 3. Low moisture absorption, 4. High dielectric strength, 5. High tensile strength, 6. Resistance to flame, 7. Flexibility at low temperatures, 8. Resistance to abrasion, 9. Resistance to chemicals, 10. Resistance to oils and greases, 11. Ease of installation, 12. Increased capacity, 13. Attractive appearance, 14. Broad color range. Remember . . . when you're thinking of PLASTIC you're thinking of US!

The[illegible]plastic insulation specialists . . . producing a complete line from [illegible] wires to heavy power cables [illegible] serving: Public Utilities, Radio, [illegible]tronic, Appliance and Instrument Manufacturers, Telephone Companies and Contractors.

PLASTIC

WIRE & CABLE CORPORATION

NORWICH CONN.

*Again Available!

LINGO

VERTICAL TUBULAR STEEL RADIATORS

*AVAILABLE NOW ONLY TO THOSE WITH PROPER PRIORITY—READY FOR QUICK SHIPMENT TO ALL, THE MOMENT PRIORITY RESTRICTION ARE LIFTED. . .

There's a Lingo Radiator and supporting pole for every need and purpose in standard heights —100 to 500 feet—for AM, FM, Television and other UHF uses. Immediate shipment to those with necessary priority. We invite your inquiries, whether your installation is large or small — for today or tomorrow.

Send for Your FREE Copy of Our New Brochure, Full of Detailed Information on Standard and Special Types of Lingo Radiators

JOHN E. LINGO & SON, INC.
Est. 1897
CAMDEN, NEW JERSEY

of the plan which has been markedly successful thus far with Ohio State University. It is expected to be of special interest to returning veterans, whose battlefield experiences has given them an awareness of the importance of technology.

Boost Program Transmission

INCREASED TIME allotment and activation of new transmitters by OWI (Office of War Information) has made it possible for shortwave news and entertainment broadcasts to men and women of the armed forces overseas to increase by 50 percent. Shortwave transmitters on the East and West Coasts now transmit more than 960 hours of such material per week.

Postwar Receiver Markets

SIX YEARS' PEAK production for the entire radio industry is anticipated postwar by Westinghouse Electric & Mfg. Co. which sees a postwar market for 60,000,000 home radio receivers.

The company's decision to re-enter the field was made on the basis of an extensive survey, and five factors were taken into consideration: (1) Frequency modulation will hasten replacements by outmoding sets; (2) Demand for radio-phonographs will increase the size of the market by increasing the average sale; (3) Establishment of new homes by returning servicemen will create a huge new market; (4) Extra sets to provide listening convenience throughout the home are expected to amount to a handsome volume; and (5) A steady growth in home television is anticipated.

Sylvania Electric Products has also dug up some facts about the postwar receiver market. Their investigation leads them to estimate that 100,000,000 radios will be sold in the first five or six years after the war. More people told them they would pay an additional $75 for television than would spend $10 extra for fm, but if they can get fm for $5 the desire is practically unanimous.

Although only 5 percent of the set owners expressed a real dissatisfaction with their receivers, nevertheless 63 percent of the families who own three sets indicated that all were made by different manu-

SOLA CONSTANT VOLTAGE TRANSFORMER
TYPE 12
SOLA
CONSTANT VOLTAGE TRANSFORMER
GLASS SEALED TERMINALS
CONSULT BULLETIN CV-102 FOR COMPLETE ELECTRICAL AND MECHANICAL SPECIFICATIONS AND OPERATIONAL CHARACTERISTICS
This equipment is designed to operate at
115 V-AC
60 cycles
As a protection against voltage fluctuations a CONSTANT VOLTAGE TRANSFORMER has been built-in as a component part of this equipment. Rated performance will therefore be maintained at all times, regardless of input voltage fluctuations as great as ±15%.

It is less expensive to provide built-in CONSTANT VOLTAGE

When you specify a SOLA Constant Voltage Transformer as a built-in part of your equipment there will be several components that you can write off your cost sheets. That's your first saving.

Now, estimate the number of anticipated service calls that would result from unstable voltages during your guarantee period. Write those off too.

Then—you can write off some sales expense, because equipment that provides its own protection against voltage sags and surges, and maintains laboratory efficiency in its operation is easier to sell.

This Type 12 SOLA Constant Voltage Transformer, is one of several small, compact units that have been designed specifically for chassis mounting. They are being successfully used by manufacturers of many types of electrical and electronic equipment. Where volume is indicated their cost is surprisingly low.

If unstable voltages have been a problem in war-time imagine what will happen when all of the much publicized electrical and electronic gadgets make their appearance on a peace-time market.

Consultation with our engineers *now* may give you the competitive advantage you are seeking for your peace-time sales.

Constant Voltage Transformers

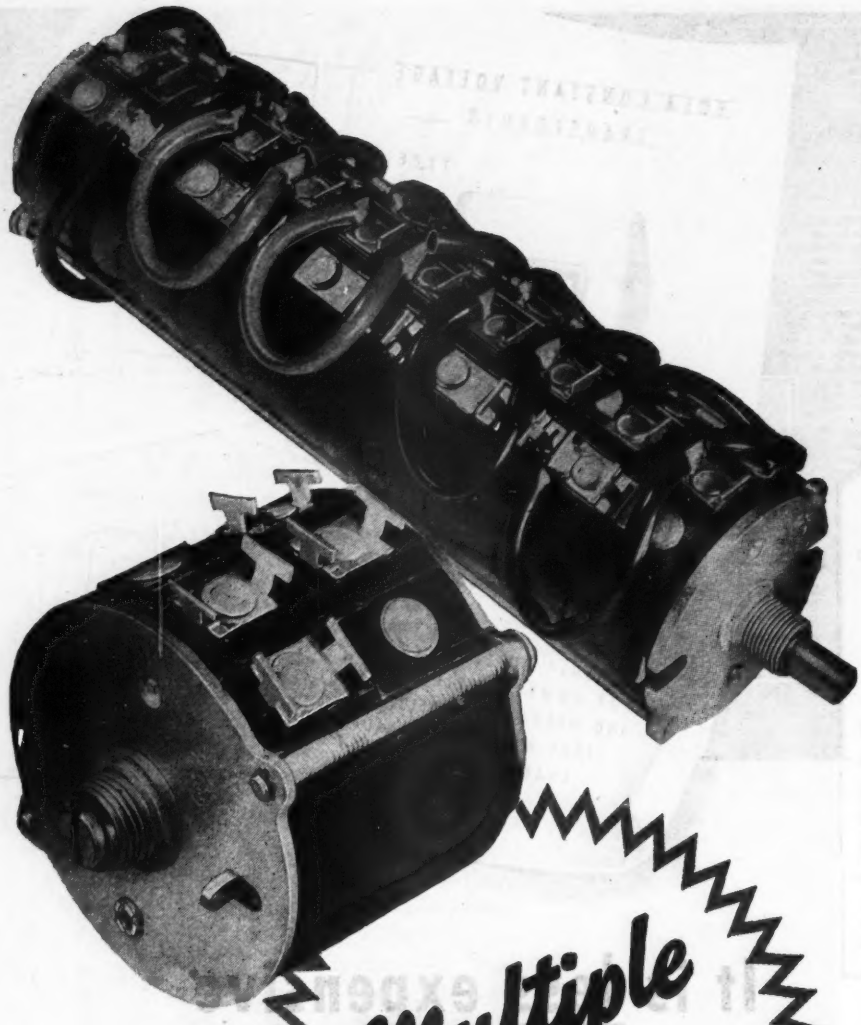
SOLA

To Manufacturers:

Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications.

Ask for Bulletin DCV-102

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.**



Multiple CONTROLS

Single shaft passes through and locks with rotor of each unit.

Each unit can be wound to precise circuit requirements, as to resistance, taper, tap, hop-off.

Interlocking resistance ratios provide any desired voltage or current at given degree of rotation.

Note dual unit with screw-driver adjustment. Such assemblies are serving in the most intricate electronic assemblies.

★ For three or more controls in tandem, Clarostat Type 42 is the logical choice. The bakelite cases of these rheostats or potentiometers nest and lock together for a virtually solid casing. Metal end plates and tie rods insure a rigid assembly—even up to 20 units in tandem. This unit is the solution to your multiple-circuit control. Back-lash is completely eliminated. And it is typical of that Clarostat "know-how" which provides the answers to all your resistor, control or resistance-device problems.

★ Submit your problem!

CLAROSTAT

Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

facturers. Push-button tuning is fairly popular. Of the 31 percent of the respondees having the feature, three-quarters like it while the rest of them report unsatisfactory service. Popularity ratings among the particular group surveyed indicate brand preferences in the following order: Philco, RCA, Zenith, Emerson, Silvertone, General Electric, Crosley, Majestic, Air Line and Stewart Warner.

Tube Standardization

TRANSMITTING, receiving, industrial, and non-industrial tubes will be standardized through the activities of JETEC (Joint Electron Tube Engineering Council). This agency is established in cooperation by RMA and NEMA. Present tube standards will not be affected. Four members will comprise the engineering council, two each of which will be from RMA and NEMA. Members are: O. W. Pike, General Electric, chairman; J. R. Steen, Sylvania Electric Products; A. Seanuke, Amperex Electronic Corp.; and D. D. Knowles, Westinghouse. Dr. W. R. G. Baker, GE and RMA, and A. C. Streamer, Westinghouse and NEMA, will be a policy committee to operate through the RMA Data Bureau.

Watts to Do About It

BROADCAST STATIONS have been asked to support the building fund campaign of IRE by keying their contributions to the power of their transmitters. Radio stations operating under 750 watts are asked to contribute 10 cents for each watt radiated, while stations over 750 watts are only called upon for 5 cents per watt.

Postwar Microwaves

TELEVISION, walkie-talkie, plane-to-plane, vehicle-to-vehicle, commercial radar and relay-link communication are only a few of the possible uses to which the transmission and reception of microwaves will be put as soon as the war is over, in the opinion of Dr. W. W. Hansen, research engineer for the Sperry Gyroscope Co., who addressed members of the IRE in Rochester recently.

He gives three reasons for this feeling: (1) Theoretically, at least,

"TAKE 'ER DOWN"

and Sickles "Submersible" R. F. Components are unharmed

WATER, corrosive chemicals and gases, even fungi are harmless to Sickles "Submersible" R. F. Components.

They are hermetically-sealed with wide soldered joints in sturdy deep-drawn zinc "hulls." They are equipped with fused metal-to-glass bushings. All adjustments are under rugged "hatches" that are sealed with Neoprene gaskets.

Permanent efficiency is sealed IN —
harmful elements are sealed OUT

Flexibility is practically unlimited. Tell us your needs, give us plenty of room and we can produce a "Submersible" R. F. Component that once installed can be forgotten.

For best in circuit components, specify Sickles.

THE F. W. SICKLES COMPANY • CHICOPEE, MASSACHUSETTS

SICKLES

Radio and Electronic Specialties for Today and Tomorrow

LAMINATED
PRECIOUS METALS
for New INDUSTRIAL USES

Laminated wire can be shaped for any industrial use, has application in many types of instruments and in any apparatus where corrosion must be prevented.

Typical uses include electrical contact strips, formed plated springs, low cost electric wire (silver-coated steel), radio electronic parts . . . where expansion must be held to a minimum (silver on invar) . . . or any project where electrical superiority, durability, or corrosion resistance is important.

Gold, silver, platinum and palladium or special precious metal alloys laminated to base metal have made these things possible . . .

- **The desirable electrical, mechanical or chemical qualities of the precious metals have been added to the strength or other desirable properties of base metals, precisely where and as required.**
- **Precious metal properties of corrosion resistance, electrical superiority, and durability are obtained without solid precious metal costs.**
- **Uniform maintenance of lamination ratios with no porosity, pit marks or defects.**
- **Finer, more lasting finishes than are otherwise obtainable in base metals.**

To assist you in the application of our products to your products we are maintaining a staff of thoroughly experienced metallurgists, chemists, designers and consultants . . . an up-to-date research and testing laboratory . . . and a splendidly equipped tool room. These are all at your service to cooperate with your own staff to the full extent of our facilities.

Your inquiries are cordially invited. Ask, too, for a copy of our new descriptive folder.

START RIGHT with Makepeace PRODUCTS

SHEETS • WIRE • TUBING • SOLDERS
FABRICATED PARTS AND ASSEMBLIES

D. E. MAKEPEACE COMPANY

Main Office and Plant ATTLEBORO MASS. New York Office, 30 Church St.

two or three million stations can operate simultaneously and in the same neighborhood without interference; (2) Passage of signals between transmitter and receiver can often be accomplished with less attenuation than is possible with longer wavelengths; and (3) The small physical size of a wavelength makes it economic and practicable to manufacture equipment larger than several wavelengths in size—necessary for relaying and projected new methods of private communication.

Receiver Licensees

COMPANIES PLANNING to produce radio receivers after the war, and therefore having arranged licenses with Radio Corp. of America, include: Bendix Aviation Corp., New York; Lear Inc., Piqua, Ohio; ARF Products, River Forest, Ill.; Medco Mfg. Co., New York; Whiting & Davis Corp., Plainville, Mass.; Concert Master Radio & Television Co., Chicago; and Ranger Electronic & Mfg. Corp., New York.

Postwar Television Receivers

RADIO CORP. of America and National Broadcasting Co. recently demonstrated an advance development model of the Schmidt-system

Large-screen television receiver of advance development type demonstrated in New York recently. Picture is 18 x 21½ in., and appears on a treated plastic viewing screen

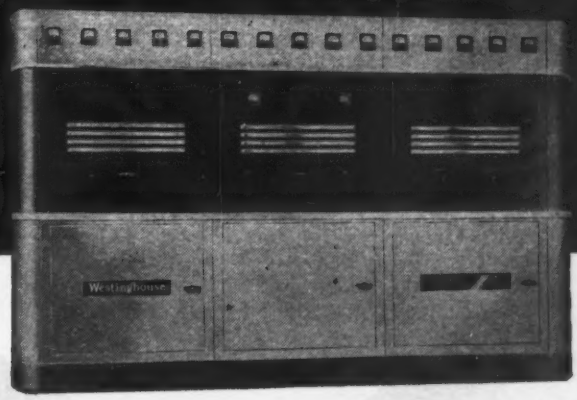
reflecting-type televison receiver described in ELECTRONICS, December 1944.

Audience reaction to the demonstration was universally good. Pictures, which came from the studio by wire line, were clear and had a bluish tone. The standard 525 lines were used and the screen was 16 x 21½ in.

Besides the reflective optical sys-

HERE'S ONE OF THE SECRETS OF HIGHER FIDELITY

IN WESTINGHOUSE TRANSMITTERS



Easy operation is another keynote of the smartly-styled Westinghouse 5kw transmitter . . . one master switch puts the transmitter on the air and cuts off power at close of broadcast day. Controls reset automatically whenever overloads occur in any circuit for any reason.

Here's one of the secrets of the higher fidelity in Westinghouse 5 and 10kw transmitters: it's called equalized audio feedback (see drawing) and it's an outstanding contribution to higher signal fidelity.

Equalized audio feedback strengthens the already high fidelity of the audio and modulation circuits in Westinghouse transmitters, and reduces audio distortion to even lower limits. The system is independent of any variation in rectified antenna output.

Control-simplicity, economy and high fidelity are natural partners of the solid dependability you find in the complete line of Westinghouse transmitters . . . 5, 10 and 50kw AM and 1, 3, 10 and 50kw FM. Your nearest Westinghouse office has all the facts on these newest achievements in faithful transmitter operation designed by Westinghouse . . . the oldest name in broadcasting. Westinghouse Electric & Manufacturing Company, P. O. Box 868, Pittsburgh 30, Pa. J-08110

XXV—RADIO'S 25TH ANNIVERSARY—KDKA

Headquarters for
SPECIAL Crystals!
The men of The James Knights Company have been designing and making special precision crystals since 1932. Their extensive experience with crystals for every conceivable purpose, coupled with an active participation in Radio dating back to 1913, is available to you. These men are interested in your special crystal problems — they have the knowledge, equipment and research facilities to help you. Why not get them working on your special crystal problem today?
JK
CRYSTALS
ILLINOIS
Sixty Miles Sou st of Chicago

tem and plastic correction lens, the unit features a built-in translucent plastic viewing screen; an automatic frequency control system, which virtually eliminates picture distortion caused by interference from noise impulses; and a new 27,000-volt cathode-ray tube. When put in production, RCA-Victor expects to market the receiver for $395.

Radar Traffic Control

ULTIMATELY, in the opinion of William P. Lear, Lear Inc., aircraft and ship traffic will be controlled by radar systems. Speaking before the Aviation Writers' Association in New York recently, he suggested that an aircraft control tower might be equipped with a cathode-ray tube several feet in diameter with spot indications for all the airborne aircraft within the traffic area involved.

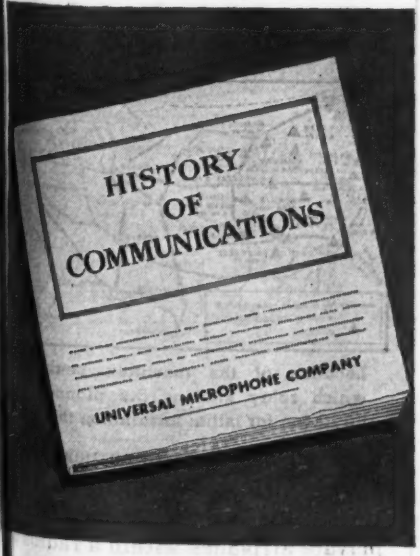
This indicator would be such as to reveal the position of planes up to a 5,000-ft. altitude and within a hundred mile radius.

From the point of view of the private flyer, other, more immediate developments described by Mr. Lear include a system of omni-directional ranges that makes it possible for a pilot to determine for himself the necessary angle to approach a given point. Such a unit is better than a direction finder since the pilot can make his correction for wind-drift to avoid flying a parabola-shaped course. This system has been made

• • •

Other members of WCEMA (West Coast Electronic Manufacturers' Association) look on as H. L. Hoffman (Hoffman Radio Corp., Los Angeles) left, shakes hands with Bud Bane (Technical Radio, San Francisco). Mr. Hoffman is retiring as president to be succeeded by Mr. Bane. Other officers include Herb Becker (Eitel-McCullough, Inc., San Bruno) as secretary and James L. Fouch (Universal Microphone Co., Inglewood) as treasurer.

UNIVERSAL'S NEW D-20 MICROPHONE



The stage was set for something new and here it is. Universal's new D-20 Microphone . . . soon on your radio parts jobbers' shelves to fill your essential requirements . . . uses Universal's "Dynoid" construction . . . A dynamic microphone of conventional characteristics built to fill the utility requirements of war time plus advance styling of the many modern things to come. Orders placed now with your Radio Parts Jobbers will assure early delivery when priority regulations are relaxed.

Write for Bulletin 1458 covering this new microphone

FREE – History of Communications Picture Portfolio. Contains over a dozen 11" x 14" pictures suitable for office, den or hobby room. Write factory for your Portfolio today.

UNIVERSAL MICROPHONE COMPANY
INGLEWOOD, CALIFORNIA

FOREIGN DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA · CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA

MEMO

TO: Postwar Designers

simplify design and reduce costs with Walker-Turner Flexible Shafting!

Reduced production costs is the key to the lower-prices, increased-sales-volume, more-jobs combination needed for post-war prosperity. Walker-Turner Flexible Shafting offers a proven way to bring about this reduction—in products involving remote control or the transmission of light power loads!

By substituting Walker-Turner Flexible Shafting for complicated gear systems in these applications, design is substantially simplified. The product is lighter, more compact. Less material is required. Costly machining is eliminated. Shipping and storage costs go down. Write today and let us put our years of flexible shafting experience to work for you!

WALKER - TURNER CO., INC.
Plainfield New Jersey

walker-turner COMPANY, INC. PLAINFIELD, N.J. U.S.A.

FLEXIBLE SHAFTING
FOR REMOTE CONTROL AND POWER TRANSMISSION

1F

possible by use of vhf and is not feasible on medium frequencies.

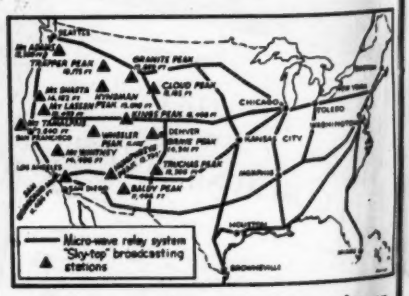
Another piece of equipment very much needed by private fliers is a small, light, inexpensive automatic pilot. This is because the necessary combination of piloting and navigational duties keep a solo flier on a cross-country hop very busy and allow little relaxation en route. It is the intention of Mr. Lear's company to supply such equipment in the postwar period.

Ten carloads of radar apparatus loaned by the Army and Navy are being used in the CAA Experimental Station at Indianapolis to conduct a series of tests aimed at the attainment of radar traffic control similar to that described by Mr. Lear. Two specific objectives are perfection of a screening device which will permit the tower controller to visualize the actual positions of all aircraft within a radius of approximately 25 miles and a collision warning device to be installed on the instrument panel of the plane, which would give constant visual indication of the relative position of other aircraft within a certain radius.

Microwave Relay System

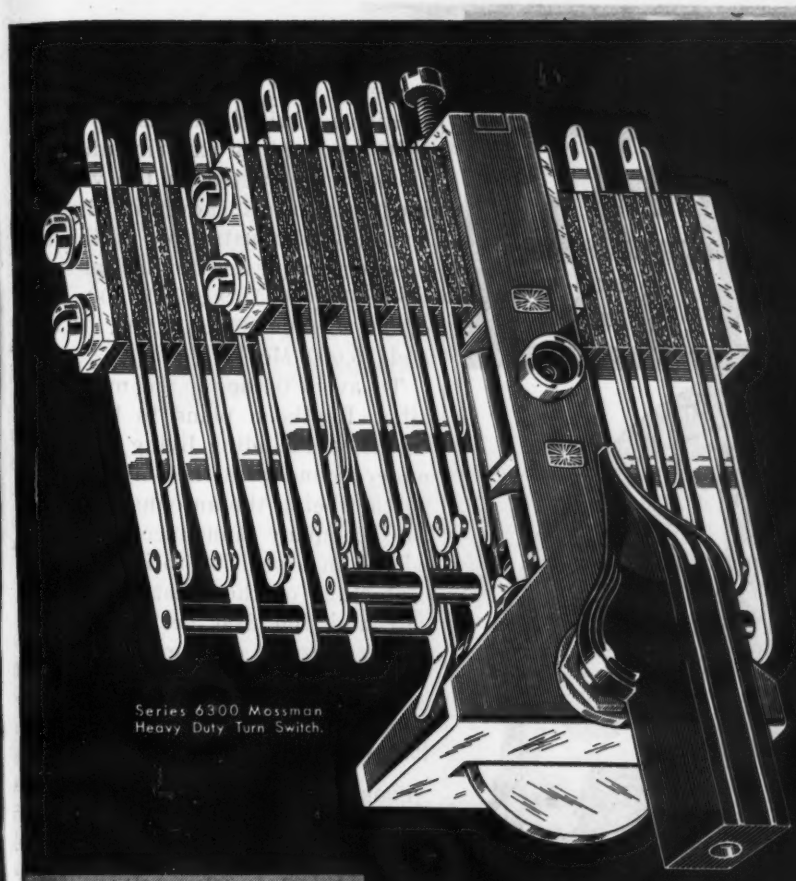
SPANNING THE HIGHEST mountain peaks from Mount Adams in Washington to Mount Whitney in Southern California, a projected West Coast installation of television broadcasting chain facilities is described by Raytheon Mfg. Co., which has filed application with FCC for experimental frequencies.

The so-called "Sky-top" chain will involve building on the sum-



Location of the mountain peaks on which relay stations are planned by Raytheon for initial installation this year

mits of several western peaks, stations which will combine the functions of safety for commercial and private airplanes within a radius of 300 to 500 miles, wide service-area television, f-m and a-m broadcast

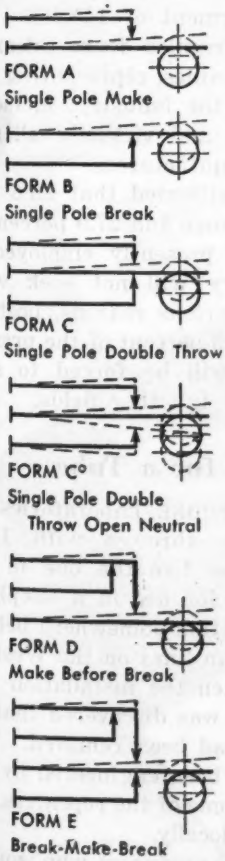


Series 6300 Mossman Heavy Duty Turn Switch.

Bracket and extended shaft for off-panel mounting.

View of mounting with gland nut for moisture-proof operation.

BASIC CONTACT FORMS



FORM A
Single Pole Make

FORM B
Single Pole Break

FORM C
Single Pole Double Throw

FORM C°
Single Pole Double Throw Open Neutral

FORM D
Make Before Break

FORM E
Break-Make-Break

MOSSMAN SERIES 6300 HEAVY DUTY TURN SWITCH

Permits Almost Unlimited Circuit Arrangements

Latest development in the Mossman line of precision heavy duty multiple circuit turn switches is the Series 6300 . . . a big, husky switch for panel mounting that permits a most versatile control set-up.

Electrical and production engineers will find this switch most useful in such applications as: Signal systems, alarm systems, controls for machine tools and welding equipment, lighting systems, annunciators and many other types of electronic devices and controls.

The Series 6300 Mossman Heavy Duty Turn Switches are available as either three position (Series 6303) or two position (Series 6302) switches. An almost unlimited series of combinations of contact assemblies may be built up by use of any combination of the six basic forms shown.

Standard heavy duty contacts are of 3/16" diameter fine silver, rated at 10 amperes, 110 volts A.C., non-inductive. Extra heavy duty contacts are of 5/16" silver alloy rated at 20 amperes, 110 volts A.C., non-inductive. Breakdown rating of springs to ground is 2000 volts, A.C.

Send for complete information on the new Series 6300 Mossman switches. Also ask for catalog which describes the full line of Mossman precision electrical components, including many types of heavy duty, multiple circuit lever switches, turn switches, push switches, plug jacks and other special switching components.

DONALD P. MOSSMAN, INC., 612 N. Michigan Ave., Chicago 11, Ill.

MOSSMAN

"Electrical" Components

There are 3 M's in MURDOCK RADIO PHONES

All 3 M's are here . . . Men, Methods, and Material . . . teamed together to produce MURDOCK Radio Phones—the keenest ears in radio reception.

To do one thing and do it supremely well is the job of every MURDOCK craftsman. It's that extra-care and attention in manufacture, assembly and inspection that results in a war-tested Radio Phone of unequalled Dependability.

But back of the men and materials is the engineering "know how" of over 40 years' experience in serving peace-time and war-time America. War-sharpened techniques and exacting methods will continue to make MURDOCK Radio Phones the No. 1 listening favorite when Victory is won.

Find out today how MURDOCK "War-Tested" Radio Phones can fit into your post-war plans.

Write for Catalog

Attention Sub-Contractors

Let MURDOCK ingenuity and experience go to work for you. Though we're busy on government work, we have facilities to help you make more Radio Phones and related parts. Write us now.

WM. J. MURDOCK CO.
179 Carter St., Chelsea 50, Mass.

ing, a microwave relay system, public call facilities, highway control systems, and police-radio master stations. Initial permission from FCC is sought for experimental stations to be erected on the various mountain peaks shown in the accompanying illustration. Authority has been requested for initial tests on 30.66, 39.55, 90, 200, 400, 900, 1,900, 4,000, 6,000, 10,000, 16,000 and 26,000 Mc.

To avoid defacing the mountain sites, Raytheon plans to build all facilities, including living quarters underground with the only exposed portion being the antenna systems. The company announced that it will be in a position to initiate the first stage of the West Coast circuit and the first section of the Eastern circuit during 1945.

Postwar Electronic Employment

ACCORDING TO THE findings of a survey made by the employment and personnel committee of RMA, the industry has a total current employment of 277,660 employees. This includes 36,374 former employees in the armed services. Results also reveal prospective postwar employment of 145,266. Figures are compiled from estimates of 202 companies, representing 64.9 percent of the industry, including the largest and virtually all substantial manufacturers.

It was estimated that 23.6 percent of the men and 27.9 percent of the women presently employed in the industry will not seek work there for various reasons, postwar and that 28.5 percent of the present employees will be forced to seek employment in other fields.

Kingdom for a Tube

BELL TELEPHONE Laboratories recently came through with 1,000 special tubes like the one in the illustration for use in a telephone repeater station somewhere behind the American lines on the Western Front. When the installation was captured it was discovered that all the tubes had been removed. The system had been engineered by the Nazis but some of the repeaters had been built locally.

One of the engineers who worked on the job was discovered and found

COILS, TRANSFORMERS AND LOUD SPEAKERS THAT JUSTIFY THE NAME... BEST

30 new BEST speakers, incorporating every advance in speaker design for a quarter of a century, achieve higher efficiency at lower cost through the use of Alnico 5 permanent magnets.

Constructed to withstand the rigorous conditions of military service, BEST hermetically sealed transformers, using every type of terminal construction, are delivered promptly and at low cost.

Transformers for varied applications, which perform to your most exacting requirements, are manufactured and tested in large quantity at BEST.

Tremendously increased winding facilities make BEST a preferred choice for bobbin or Universal wound coils of all types and sizes. The coil illustrated is hand layer-wound #42 wire.

The name BEST has been associated with the finest in coils, transformers and loud speakers since the days of radio's infancy. Illustrated are but a few of the many items manufactured by BEST which required skill, precision and efficiency. Because of the experience gained throughout the years, BEST has been able to meet the ever growing demands of this industry for greater quality, durability and quantity production.

We Invite Inquiry

Our modern production facilities are now available for the quantity production of coils and transformers of all types. Your inquiry will receive our immediate attention.

BEST MANUFACTURING CO., INC.

Electronic and Sound Reproducing Equipment

1200 GROVE STREET • IRVINGTON 11, N. J.

From Your Specifications

BLAW-KNOX

WILL DESIGN, FABRICATE AND ERECT

The Latest Development in

VERTICAL RADIATORS

and Towers for

FM *and* TELEVISION ANTENNAE

Station Engineers take a load off their shoulders when their antenna problem is turned over to Blaw-Knox. Specifications are completed under one responsibility. The job is not done until the tower is up, tested and approved.

BLAW-KNOX DIVISION

of Blaw-Knox Company

2077 Farmers Bank Bldg.

Pittsburgh Penna.

capable of supplying some of the electrical characteristics of the badly needed tubes and eventually a single sample tube was found. The tube and the notes were rushed to New York and to the electronics department of the Laboratories. Electrical tests showed that there was no American telephone repeater tube suitable for substitution but that, with the exception of one grid and a base, a tube could

be built up from parts of various existing units. Special grid production was started, various machines were modified to suit the circumstances, and within three days eight tubes with handmade bases were on their way. Without waiting to hear the results from the prototypes, production was pushed along and on the seventeenth day the thousandth tube was waiting for shipment. PS, they worked all right.

Resistance Welding Prizes

ANNOUNCED BY RWMA (Resistance Welder Manufacturers Association) is this year's prize contest to encourage the preparation of outstanding papers on resistance welding subjects. The scope of former contests has been increased, bringing the total amount of the awards up to $1,000. Additional information can be obtained from Harold S. Card, educational director, RWMA, Citizens Building, Cleveland 14, Ohio.

Technical Oscars

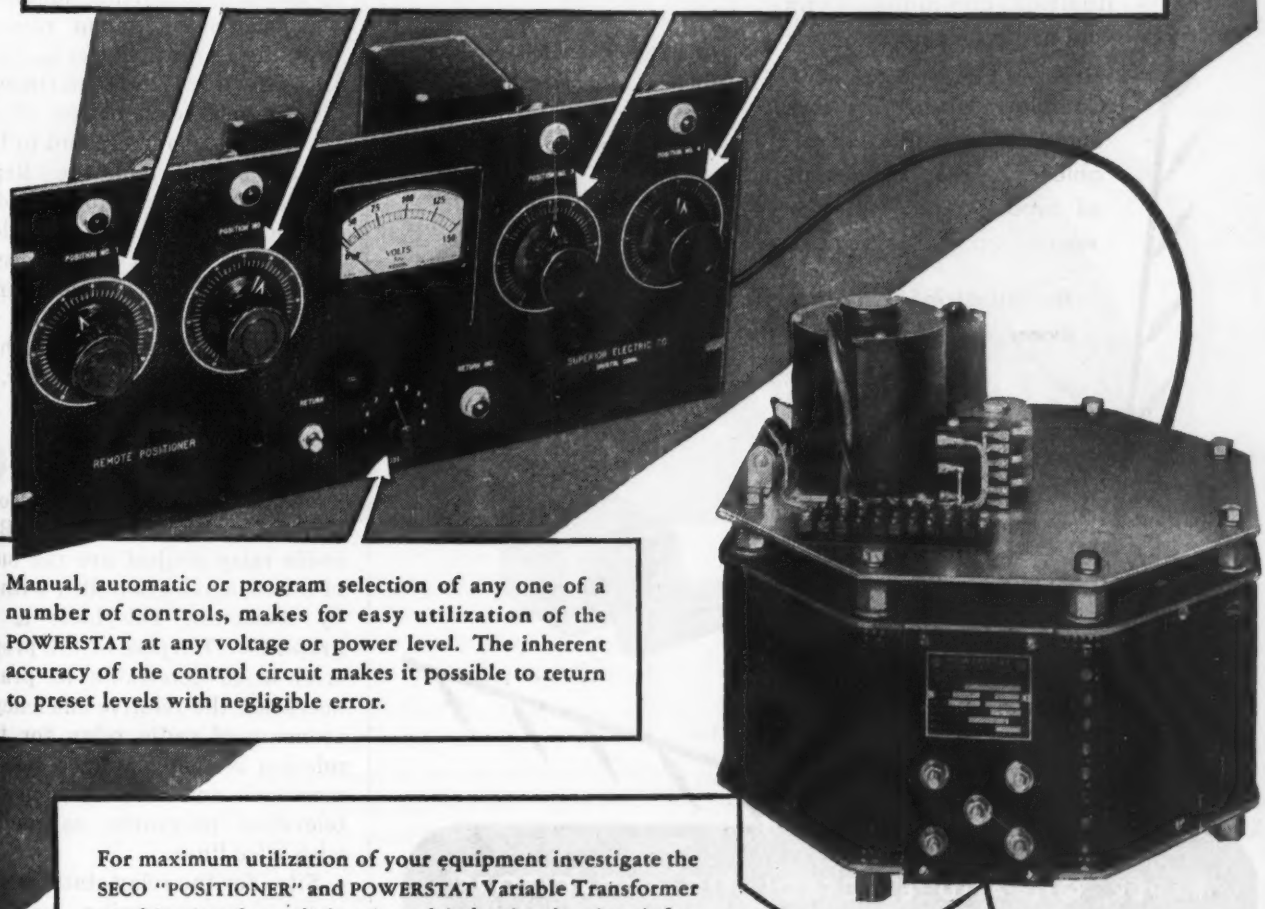
AWARDS BY THE Research Council of the Academy of Motion Picture Arts and Sciences have been announced for scientific or technical achievements during 1944. No award was made in Class I—the statuette corresponding to the familiar Oscars given to star performers.

A single Class II or plaque award

IT'S NEW

A servo-type VOLTAGE CONTROL

SECO'S "POSITIONER" will enable you to remotely and accurately set the output voltage of a POWERSTAT variable transformer. Control wires between the "POSITIONER" and the motor operated POWERSTAT serve as an "electrical flexible shaft". This type of coupling means servo operaton of the POWERSTAT variable transformer from a remotely located control dial.



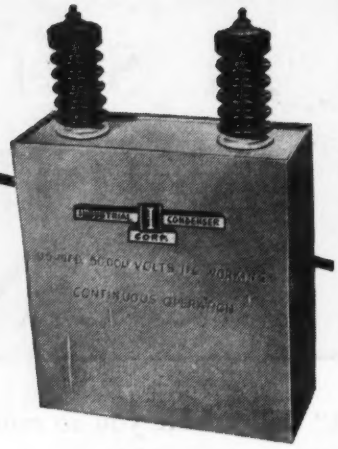
Manual, automatic or program selection of any one of a number of controls, makes for easy utilization of the POWERSTAT at any voltage or power level. The inherent accuracy of the control circuit makes it possible to return to preset levels with negligible error.

For maximum utilization of your equipment investigate the SECO "POSITIONER" and POWERSTAT Variable Transformer combination for... dielectric and induction heating, infrared drying, photographic applications, and vacuum tube manufacture. Only SECO offers the motor-driven POWERSTAT Variable Transformer with SERVO control. SECO'S engineering staff will be pleased to assist with your applications.

Send for Bulletins LE

SUPERIOR ELECTRIC COMPANY

404 LAUREL STREET • BRISTOL, CONNECTICUT



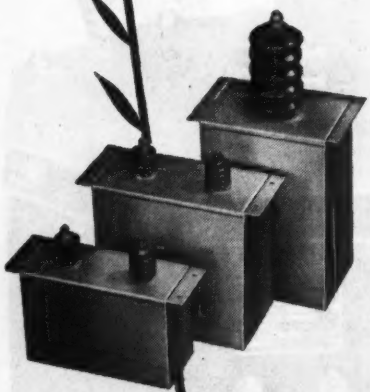
Unsurpassed
QUALITY

• The Industrial Condenser Corporation manufactures a complete line of Oil-filled, Electrolytic, Wax and Special Mica Capacitors for all industrial, communications and signalling applications up to 250,000 volts working. Complete laboratory and engineering facilities available for solution and design of capacitor problems for special applications.

An Industrial Condenser for every industrial application.

.5 MFD. 50,000 VOLTS DC WORKING

(Illustrated above)...28 inches high, weight 175 pounds, built by Industrial Condenser Corporation to meet Navy specifications. Oil-filled, oil impregnated. Built for 24 hour continuous operation and total submersion in salt water.



PAPER, OIL AND ELECTROLYTIC CAPACITORS

INDUSTRIAL CONDENSER CORPORATION

3243 65 NORTH CALIFORNIA AVE., CHICAGO 18, U.S.A.

DISTRICT OFFICES IN PRINCIPAL CITIES

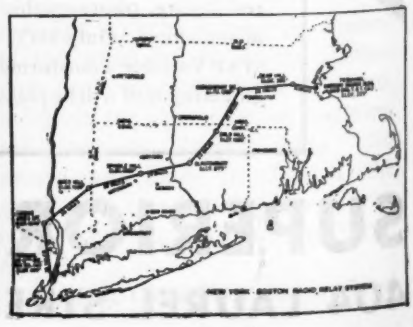
was made to Stephen Dunn and the RKO Radio Sound Department for design, and to Radio Corp. of America for additional development of the electronic compressor-limiter, a variable gain amplifier, the design of which is based on the logarithmic characteristics of hearing. Use of the compressor-limiter in a recording system is described as providing automatic control of intensity ratios and permitting the reproduction of sound, particularly speech, without exaggerated and unnatural volume surges. Intelligibility is increased.

Class III Awards consist of honorable mention in the report of the Research Council. Among others, such awards were given to Western Electric Co. for the design and construction of a limiting amplifier for variable-density sound recording; to Radio Corp. of America and the RKO Radio Sound Department for design and construction of a reverberation chamber; and to Daniel J. Bloomberg and the Republic Sound Department for the design and development of a six-pole six-position switch for use in selsyn interlock systems. These eliminate the usual multiple patching plugs and cable connections which prevail throughout the industry.

Trial Radio Relay

SEVEN RELAY STATIONS between the terminals of the New York-Boston radio relay project are the subject of a new application filed with FCC by American Telephone & Telegraph Co. Purpose of the proposed trial is to determine in practical operation the relative efficiency and economy of radio relay for transmission of long distance telephone messages and also of sound and television programs, as compared with wire lines.

Sites for the relay stations shown on the accompanying map were



Preview of Lear's next National Advertisement

Here you see the next advertisement in the Lear advertising campaign on wire recording and home radios. It is going to appear in:

Collier's, Aug. 11th • Fortune, June
Liberty, June 10th • Atlantic, June
New Yorker, May 26th
New York Times Magazine, May 6th

This means that 5,400,000 regular readers of these magazines, their families and friends, will see again the advantages of owning a Lear Home Radio with wire recording.

If you want to be able to offer Lear Radios with wire recording, write for information on the Lear Franchise.

Listen! That's your own voice you hear. Or a radio program caught and recorded straight from the air. Or maybe a program produced by your own youngsters.

It all comes from the thin wire that runs through the Lear Wire Recorder—a wire magnetically impressed with sound through an entirely new method of recording brought to its present high state in Lear laboratories.

Wire recording will be a part of Lear Home Radios. But home entertainment is only one of countless sensational applications. Think of a dictating machine with no records to break or keep shaved—and business conferences, meetings, telephone conversations kept precisely and permanently for future reference.

No one has yet begun to explore the full realm of possibilities that lie in Lear Wire Recording. But to give you a glimpse of how it works and a few of the ways it can be used, Lear has prepared a free booklet of questions and answers. Would you like one? Just drop us a line—or mail the coupon below.

LEAR RADIO

Grand Rapids 2, Michigan
Home Radio Sales: 230 E. Ohio St., Chicago 11, Illinois

LEAR, Incorporated
Home Radio Sales Division,
230 East Ohio Street, Chicago 11, Illinois.
Gentlemen:
Please send me your free booklet on Wire Recording offered in Lear national magazine advertising.

*Firm Name*_____
*Individual*_____
*Address*_____

ERCO VHF RECEIVERS

For dependable VHF communications

ERCO

An addition to the popular 32 series of fixed frequency crystal controlled receivers, the new 32-E is intended for exacting VHF applications in the range of 100 to 160 MC. Equipped with carrier operated audio gate and automatic noise suppressor. Selectivity pass band X2=60KC wide, X10=90KC wide and X100=120KC wide. Components are designed for continuous operation during wide variations of ambient temperature and humidity. Panel mounted; 8¾ inch relay rack panel.

The type UHC coaxial half wave dipole antenna can be supplied for operation on any desired frequency between 30 and 500 MC. Sound engineering, backed by seven years of experience, are incorporated in this new model. Will withstand winds of high velocity and serious icing conditions. This antenna may be obtained in stacked colinear arrays for securing added transmitter and receiver gain over a 360 degree area. Inquiries are invited.

ARMY E NAVY

ERCO RADIO LABORATORIES INC

HEMPSTEAD, NEW YORK

Manufacturers of CUSTOM BUILT RADIO APPARATUS

chosen for their elevation and facilities will be provided at the seven points to house transmitting and receiving apparatus. Field work during the coming year is expected to include building of roadways up to the hillsides to the relay station sites and similar preparatory work. Eight channel assignments are being asked—each 20 Mc wide—near 2,000, 4,000 and 12,000 Mc.

If the experimental facilities prove as satisfactory as company engineers expect, apparatus will be standardized in order that the Bell System may be prepared to install similar systems throughout the country as the need develops.

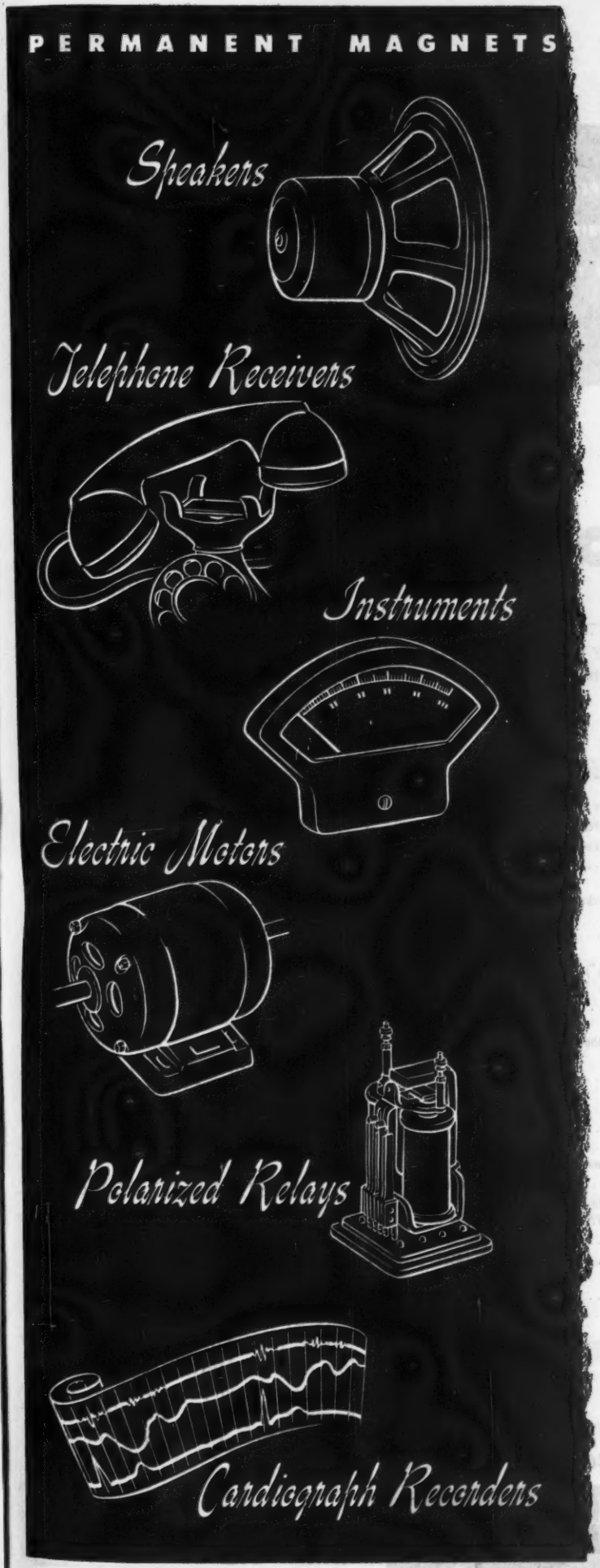
Ten Join RMA

New RMA member companies include American Coil & Engineering Co., Chicago; Chicago Condenser Corp., Chicago; Electrical Reactance Corp. Franklinville, N. Y.; Jackson Industries, Chicago; Measurements Corp., Boonton, N. J.; Minerva Corp. of America, New York; J. P. Seeburg Corp., Chicago; Sherron Electronics Co., Brooklyn, N. Y.; U. S. Television Mfg. Corp., New York; and the Zell Co., New York.

NAB Grows

ACCORDING TO figures recently released, National Association of Broadcasters now has 654 active members and 37 associate members, or a total of 691. Active membership includes 635 a-m stations, 16 f-m stations, 1 television station, and 2 networks.

Recent activities within the association include the nomination of a number of individuals to be directors-at-large. Under each of the following classifications two directors are to be chosen: Large stations—W. H. Summerville, WWL, New Orleans, La.; J. Leonard Reinsch, WSB, Atlanta, Ga.; J. O. Maland, WHO, Des Moines, Iowa; Lee B. Wailes, KYW, Philadelphia, Pa.; Paul W. Morency, WTIC, Hartford, Conn.—Medium stations—G. Richard Shafto, WIS, Columbia, S. C.; T. A. M. Craven, WOL, Washington, D. C.; Robert E. Priebe, KRSC, Seattle, Wash.; Clarence T. Hagman, WTCN, Minneapolis, Minn.; E. E. Hill, WTAG, Worcester, Mass.; F. M. Doolittle, WDRC, Hartford, Conn.; George



MAY DO IT BETTER

This is the second in a series of four advertisements discussing the four major functions of permanent magnets

MECHANICAL ENERGY from ELECTRIC CURRENT through PERMANENT MAGNETS

The electric motor demonstrates how mechanical motion can be produced by the passage of an electric current with respect to a magnetic field set up by permanent magnets. Industry and science are making many profitable uses of this principle.

Mechanical energy may be transmitted to electrons moving in space to cause them to take a desired direction. A permanent magnet has been used, for example, to change the path of a cosmic ray in a cloud chamber. X-rays may be similarly directed; or the path of electrons in a magnetron tube can be changed.

The permanent magnet may be used as a polarizing agent, remaining stationary while mechanical motion is obtained by varying the magnetic field through variations in the applied electrical energy. Telephone receivers, magnetic recording heads, polarized relays, armature-type loud speakers, and some kinds of vibrators employ this principle.

For specific applications of permanent magnets to your problems of product improvement, consult our engineers. For 35 years we have specialized in the manufacture of permanent magnets and are today the largest plant in the world in this field. Write for copy of free technical booklet: "Permanent Magnets Have Four Major Jobs."

★ THE INDIANA STEEL PRODUCTS COMPANY ★

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

ARMY E NAVY

Specialists in Permanent Magnets Since 1910

Laminated INSUROK T-712

Melamine Fiberglass Laminate—INSUROK T-712—is a brown plastic product of the type requested by the Navy for all electrical power, lighting, interior communications, fire control and other shipboard electrical installations.

● Laminated INSUROK T-712 is superior to many other types of sheet insulation in fire and arc resistance. It has reduced toxicity in the case of unavoidable fires; does not readily support combustion; is higher in mechanical and electrical properties; lower in expansion under heat and moisture, and has high tensile and compressive strengths. Richardson Plasticians have also developed modern and economical methods of fabricating this product. Write today for complete information on Laminated INSUROK Grade T-712!

TESTS OF FACTORY-RUN INSUROK T-712
Made at Richardson Laboratories

Tensile strength ⅛" thickness	
Lengthwise	45,600 psi.
Crosswise	37 900 psi.
Flexural strength ⅛" thickness	
Lengthwise	53,700 psi.
Crosswise	50,400 psi.
Compressive strength	
Flatwise (½"x½"x½")	97,800 psi.
Edgewise (½"x½"x½")	
Lengthwise	29,460 psi.
Crosswise	24,600 psi.
Impact strength Izod method per inch of notch	
Flatwise (½"x¼")	
Lengthwise	Greater than 33 ft. lbs.
Crosswise	27.4 ft. lbs.
Edgewise (½"x¼")	
Lengthwise	18.8 ft. lbs.
Crosswise	16.5 ft. lbs.
Bond strength ½" thickness	1,800 lbs.
Arc Test	185 sec.
Moisture Absorption ⅛" thickness	
24 hours in water at 77° F.	1.84%
Dielectric Constant	5.65
Loss Factor	.0521
Dielectric Strength	
Short Time	590 volts/mil
Step by Step	410 volts/mil

INSUROK *Precision Plastics*

The RICHARDSON COMPANY

MELROSE PARK, ILL. · NEW BRUNSWICK, N. J. · FOUNDED 1858 · INDIANAPOLIS 3, IND. · LOCKLAND, CINCINNATI 15, OHIO
DETROIT OFFICE: 6-257G MOTOR BUILDING, DETROIT 2, MICHIGAN · NEW YORK OFFICE: 75 WEST STREET, NEW YORK 6, N. Y.
CLEVELAND OFFICE: 926 PLYMOUTH BLDG., CLEVELAND 15, OHIO

M. Burbach, KSD, St. Louis. Mo.—Small stations—Dietrich Dirks, KTRI, Sioux City, Iowa; Frank King, WMBR, Jacksonville, Fla.; Clair R. McCollough, WGAL, Lancaster, Pa.; Dale L. Taylor, WENY, Elmira, N. Y.; Matthew H. Bonebrake, KOCY, Oklahoma City, Okla.; and Marshall Pengra, KRNR, Roseburg, Oregon.

A special committee is working on the task of selecting a president to succeed Harold Ryan, whose term expires on July 1 and who has indicated his intention of giving up the office at that time.

Sound Reproduction Standards

AT THE REQUEST of the Armed Forces, ASA (American Standards Association) has completed a group of three standards designed to assure high fidelity in film sound reproduction.

All these standards deal with test methods for 16-mm sound motion picture prints. One, Z52.15, covers a method of making intermodulation tests on variable density prints; the second, Z52.39, describes a method of making cross-modulation tests on variable area prints; the third, Z52.38, is on a method of determining signal to noise ratio.

Each standard is divided into sections covering scope and purpose, test method, and test equipment. It is planned to specify limits of allowable sound distortion as a basis for acceptance or rejection of individual prints as soon as experience in the use of these tests is wide enough to warrant setting up definite limits.

MEETINGS TO COME

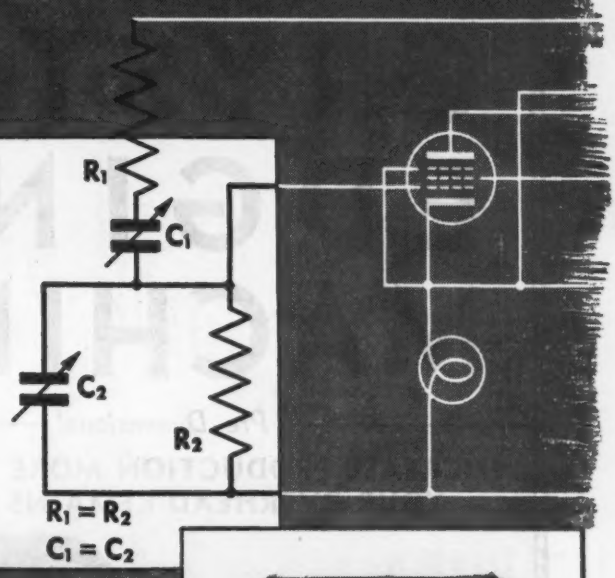
APRIL-MAY; NATIONAL ASSOCIATION OF BROADCASTERS, Annual Conference. . . . Cancelled.

MAY 2; INSTITUTE OF RADIO ENGINEERS, New York Section; Television, by P. I. Merryman, director of facilities development, NBC; Engineering Societies Building, New York, N. Y.; J. T. Cimorelli, secretary, Radio Corp. of America, Harrison, N. J.

MAY ——; SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, 1945

hp laboratory instruments for speed and accuracy

This fundamental circuit is the key to -hp- audio oscillator efficiency



$$f = \frac{1}{2\pi RC}$$

The resonant frequency of this network is inversely proportional to the product of resistance and capacity. Thus wide change in resonant frequency is practical with commercially available condensers. A decade gang switch to change resistances enables operator to cover a wide range in the easiest possible manner. This circuit is the basic reason why *-hp-* Resistance-Tuned Audio Oscillators are so easy to use.

This resistance-capacity network is operated in conjunction with a

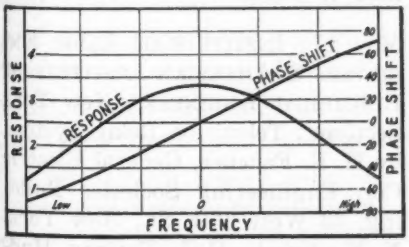


FIGURE 1

stabilized amplifier. Positive feedback is applied to this amplifier through the R-C network. The result is a very high effective "Q" for the circuit, which, combined with the phase shift characteristics of the network, provides an extremely stable output frequency. See Figure 1.

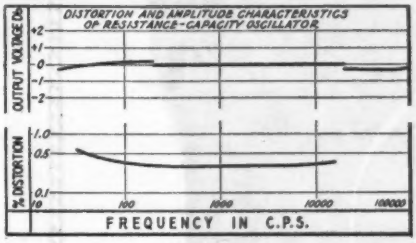
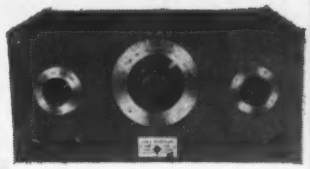


FIGURE 2

The unique balancing circuit automatically selects the proper operating point, keeps distortion at a remarkably low level, and maintains uniform output over the entire frequency spectrum. See Figure 2.

-hp- Audio Frequency Oscillators require no zero setting

It's just such engineered features as these that have made *-hp-* the outstanding laboratory instruments in the field today. Simplicity of operation... speed in making measurements without sacrifice of accuracy ... that's the keynote of all *-hp-* instruments. Write for information... *-hp-* engineers are at your service.



-hp- Resistance-Tuned AUDIO OSCILLATORS cover a wide range

-hp- Model 200-A

Frequency range, 35 cps to 35 kc. In 3 ranges: 35 to 350 cps, 350 to 3500 cps, 3500 cps to 35 kc.

-hp- Model 200-B

Frequency range, 20 cps to 20 kc. In 3 ranges: 20 to 200 cps, 200 to 2000 cps, 2000 cps to 20 kc.

-hp- Model 200-C

Frequency range, 20 cps to 200 kc. In 4 ranges: 20 to 200 cps, 200 to 2000 cps, 2000 cps to 20 kc, 20 kc to 200 kc.

-hp- Model 200-D

Frequency range, 7 cps to 70 kc. In 4 ranges: 7 to 70 cps, 70 to 700 cps, 700 to 7000 cps, 7000 cps to 70 kc.

-hp- Model 202-D

Frequency range, 2 cps to 70 kc. The Model 202-D is similar to the Model 200-D, with the addition of a 2-50 cps band covering approximately 200 degrees on the main tuning dial.

-hp- Model 200-I

Frequency range, 6 cps to 6000 cps. In 6 ranges: 6 to 20, 20 to 60, 60 to 200, 200 to 600, 600 to 2000 and 2000 to 6000 cps.

All the above models are available in cabinets or for relay rack mounting.

HEWLETT-PACKARD COMPANY

BOX 1042A • STATION A • PALO ALTO, CALIFORNIA

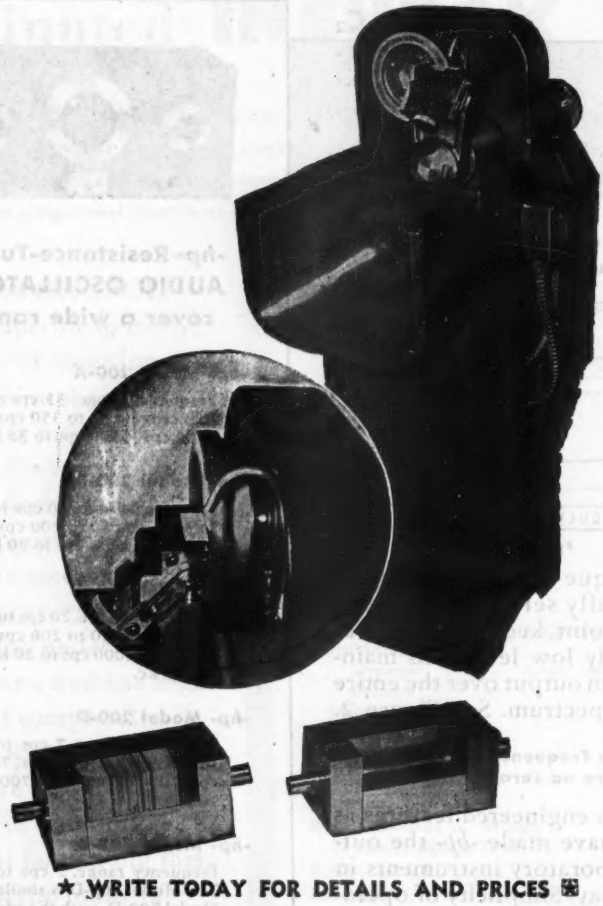
Audio Frequency Oscillators · Signal Generators · Vacuum Tube Voltmeters
Noise and Distortion Analyzers · Wave Analyzers · Frequency Meters
Square Wave Generators · Frequency Standards · Attenuators · Electronic Tachometers

New - Sensational

CRYSTAL EDGING MACHINE

Pre-Dimensional

INCREASE PRODUCTION MORE THAN 50%
— YOUR OVERHEAD REMAINS STATIC —



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VOLKEL BROS.
MACHINE WORKS

1943 West Manchester · Los Angeles 44, Calif.

Designers and Manufacturers of
SPECIAL DEVICES & EQUIPMENT

Spring Meeting, Buffalo, N. Y. W. M. Murray, president, P.O. Box 168 Central Square Station, Cambridge 39, Mass. Subject to postponement or cancellation.

MAY 3; INSTITUTE OF RADIO ENGINEERS & AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, New York Sections; Comparison of Various Modulation Methods in Higher Frequency Communication, by W. R. MacLean, Brooklyn Polytechnic Institute; Engineering Societies Building, 33 West 39 St., New York, N. Y.; tickets, G. L. Tawney, Hudson American Corp., 300 Pearl St., Brooklyn 1, N. Y.

MAY 10; INSTITUTE OF RADIO ENGINEERS & AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, New York Sections; Radiation and Propagation in Higher Frequency Communication by C. W. Hansel, RCA Laboratories; Engineering Societies Building, 33 West 39 St., New York, N. Y.; tickets, G. L. Tawney, Hudson American Corp., 300 Pearl St., Brooklyn 1, N. Y.

MAY 11-12; ACOUSTICAL SOCIETY OF AMERICA, thirtieth Meeting; Hotel Pennsylvania, New York, N. Y.; Wallace Waterfall, secretary, 350 Fifth Ave., New York 1, N. Y.

MAY 14-18; SOCIETY OF MOTION PICTURE ENGINEERS, 57th Semi-Annual Technical Conference; Hollywood-Roosevelt Hotel, Hollywood, Calif; W. C. Kunzmann, convention vice president, P.O. Box 6087, Cleveland 1, Ohio.

MAY 17; INSTITUTE OF RADIO ENGINEERS & AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, New York Sections; Television Relay System, by H. B. Fancher, General Electric Co.; Engineering Societies Building, 33 West 39th St., New York, N. Y.; tickets, G. L. Tawney, Hudson American Corp., 300 Pearl St., Brooklyn 1, N. Y.

MAY 18; INSTITUTE OF RADIO ENGINEERS, Chicago Section; Current Problems in Radio Engineering and Manufacturing, by Paul Galvin, president, Galvin Mfg. Corp.; Central YMCA, 19 South LaSalle St.; Alois W. Graf, secretary, 135 South LaSalle St., Chicago 3, Ill.

MAY 23; AMERICAN INSTITUTE OF ELECTRICAL ENG'RS, N. Y. section,

The Television Dream That Cables Make Possible

TELEVISION—sign and symbol of the age to come—is one of the wonders that specially designed cable transmission makes practical. For the quality and fidelity of the transmitted image depend largely on how well the cables are engineered and manufactured, from tiny cables in the broadcasting mechanism itself to the great coaxial cables linking city with city, making possible the television networks of the future.

Thus the "wireless age" as it develops will actually need more wires—and more complicated cables—to achieve its realization! And in the solution of these problems, new and more complicated cables will be required.

Today, we will undertake to engineer and manufacture the radio and audio cable requirements of any government agency or private concern in war work. Moreover, we look forward to solving many of the most difficult cable tasks in peacetime—as we have in wartime. The same laboratories, the same Yankee ingenuity that have helped to whip many of the difficulties involved in the communications requirements of our Army and Navy are prepared to function for industry—whatever the problems of today and tomorrow.

Why ANKOSEAL *solves cable problems*

Ankoseal, a thermoplastic insulation, can help solve many electrical engineering problems, now and in the future. *Polyvinyl* Ankoseal possesses notable flame-retarding and oil resisting characteristics; is highly resistant to acids, alkalies, sunlight, moisture, and most solvents. Polyethylene Ankoseal is outstanding for its low dielectric loss in high-frequency transmission. Both have many uses, particularly in the radio and audio fields. Ankoseal cables are the result of extensive laboratory research at Ansonia—the same laboratories apply engineering technique in the solution of cable problems of all types.

THE ANSONIA ELECTRICAL COMPANY

Specializing in "Ankoseal" a Thermoplastic Insulation

ANSONIA • CONNECTICUT

A Wholly-Owned Subsidiary of

NOMA ELECTRIC CORPORATION

GENERAL OFFICES • NEW YORK, N. Y.

—In peacetime makers of the famous Noma Lights—the greatest name in decorative lighting. Now, manufacturers of fixed mica dielectric capacitors and other radio, radar and electronic equipment.

ABOVE is a portion of the Electrical Engineering Department, which contributes to the unusual Unionair set-up that is at present producing Electrical Assemblies for the war effort. This department converts customers' drawings and sketches to Unionair production drawings and where required, creates its own designs in connection with Electrical Equipment.

When the time comes that we can put to Commercial use the results of the concentrated research and development of the war years in Electrical Assemblies, these engineering facilities may be yours.

Our new booklet titled, "Electrical Assemblies made to Customers' Specifications" is available on request. Write to: Union Aircraft Products Corp., Dept. E, 245 East 23rd Street, New York 10, N. Y.

ARMY E NAVY

UNIONAIR

Electrical Assemblies — Hydraulic Fittings
Conduit Fittings — Junction Boxes

UNION AIRCRAFT PRODUCTS CORP. NEW YORK

Focusing of Electron Beams, by Dr. E. U. Condon, associate director of research, Westinghouse Electric & Mfg. Co.; Pupin Laboratory, Columbia University, New York, N. Y.; Prof. C. W. van der Merwe, symposium chairman, dept. of physics, Washington Square College, New York University, New York, N. Y.

MAY 28; AMERICAN SOCIETY FOR MEASUREMENT & CONTROL; Control of Industrial Processes, by W. B. Heinz, Cochrane Corp.; Roosevelt Hotel, Pittsburgh, Pa.; L. M. Susany, secretary, Carnegie Institute of Technology, 4400 Forbes St., Pittsburgh 13, Pa.

JUNE 25-29; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, Summer Technical Meeting; Detroit, Mich.; H. H. Henline, secretary, 33 West 39 St., New York 18, N. Y. . . . Cancelled.

WASHINGTON NEWS

PRODUCTION. Looking toward a greater production effort in 1945 than was available in 1944, WPB points out that in the January and February schedules this year, communication and electronic equipment increased 10 percent. Summed up for the year 1944, actual production was $4,185,000,000, while December production was $335,000,000. As of January 1, 1945, the January schedule was $354,000,000 and the February schedule $380,000,000. It was also revealed that cumulative figures from July 1, 1940 through December, 1944 showed communication and electronic equipment standing at a total value of $9,405,000,000, with radio at $4,459,000,000 and electronic equipment at $2,827,000,000.

RETURNED MATERIEL. Under a new arrangement within the Signal Corps, supervision of all shipments of returned materiel from overseas will be handled by an organization at the Holabird (Md.) Signal Depot. Shipping instructions will be sent to every Atlantic port on all signal items which can be identified, assigning them to the different Signal Corps installations around the country. About 90 percent of all materiel is unidentified. This will be

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SUPER-QUALITY COILS AT REASONABLE PRICES

More and more every day, the industry is turning to Albion for fast, quality and quantity production of coils, chokes, and transformers. That's because here you benefit from the unbeatable combination of management "know how," skilled workmanship, streamlined facilities, and central location. Your requirements will be given prompt and thoughtful attention.

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R. F. AND TRANSMITTING COILS AND CHOKES;
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FOR POST-WAR REQUIREMENTS

40 YEARS OF EXPERIENCE AT YOUR SERVICE

Willor Makes It!

. . . and makes it with a high degree of precision and cooperation born of our concentrated experience in meeting wartime's rigid requirements and schedules. From raw stock to completed items . . . Willor service embraces every facility for planned production.

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- METAL STAMPINGS
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- TOOLS AND DIES
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- PLASTIC PARTS
- MECHANICAL AND ELECTRICAL INSTRUMENTS

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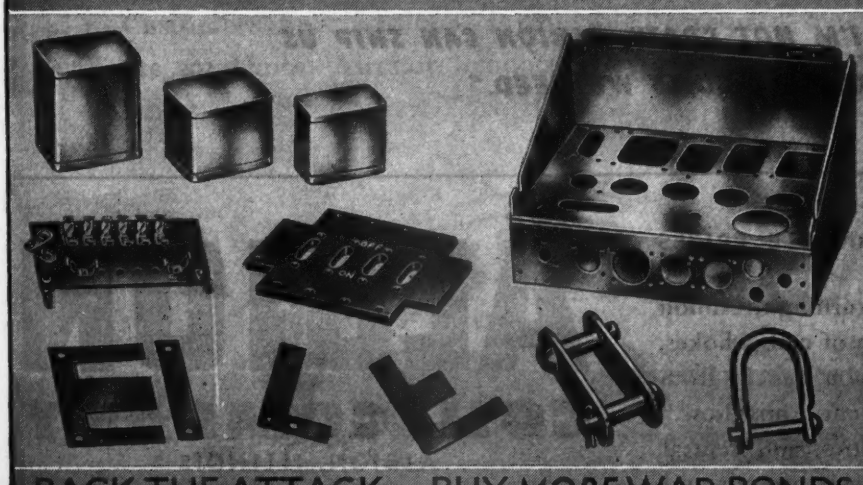
794 E. 140th St., New York (54) N. Y.



BACK THE ATTACK -- BUY MORE WAR BONDS

sent to Holabird where after examination it will be classified as serviceable, repairable, obsolete, excess, surplus or salvage. Serviceable materiel will be sent where needed, and obsolete apparatus will be dismantled so that parts can be used where possible. Materiel rated as salvage will be shipped to the salvage disposal division and simple repairs will be done. Materiel which can be repaired by the use of specialized equipment will be sent to various Signal Corps depots where the required equipment is available.

SURPLUS PRODUCTS. Toward the end of April, Section XI of a handbook of standards for describing surplus property was announced by Surplus Property Board. This section covers communications equipment, electronic devices, and alarm and signal control equipment. Produced to establish minimum standards for contractors and government owning agencies in describing inventories, the handbook will consist of 22 sections, 13 of which have been previously issued. In a still later section will be included instrument control apparatus, including scientific and professional equipment and supplies. Copies will be purchasable from the Superintendent of Documents, Washington, D. C.

SHORTAGES. Electron tubes still being in short supply, WPB is simultaneously trying to get all existing tubes in service and to obtain the maximum volume of new tube production. Information as to surplus radio receiving tubes is made available to manufacturers and distributors, so that any actual surplus supplies may reach dealers and service men for civilian supply. This does not mean that the civilian tube supply situation will improve materially. Rather, it is expected to remain about the same as in late 1944, approximately one and one-half million tubes a month.

Although available production capacity is believed to be greater than military needs, transformers were reported as becoming critical again and closer control by WPB is anticipated.

Aluminum phonograph records are available only on high rated orders, remaining supplies being available only to broadcasting sta-

When You *Don't* Want to Draw Power

USE THIS

NEW D-C VACUUM-TUBE VOLTMETER

- WIDE RANGE
- HIGH INPUT RESISTANCE
- GOOD ACCURACY
- NO A-C EFFECT
- PORTABLE
- BATTERY OPERATION

HAVING the very wide d-c voltage range of 0.05 to 3,000 volts with exceptionally high input resistance, this new d-c v-t voltmeter is very useful in radio and electronic circuit design and testing.

Small, portable, lightweight, self-contained and accurate the new Type 728-A Voltmeter is especially useful when voltage measurements have to be made without drawing power from the circuit.

FEATURES

WIDE RANGE — 0.05 to 3,000 volts, in 7 full-scale values of 3, 10, 30, 100, 300, 1000 and 3000 volts, d-c

HIGH INPUT RESISTANCE — Over 5000 megohms on ranges below 100 volts; 1000 megohms above

GOOD ACCURACY — within ±3% of full-scale on low ranges to 30 volts; within ±5% on higher ranges

NEGLIGIBLE A-C EFFECT — superimposed a-c voltage up to 200 has negligible effect on meter indication

REVERSING SWITCH — switch on panel to ground either positive or negative terminal of source being measured

BATTERY OPERATED — instrument supplied complete with batteries

PORTABLE — weighs only 9¾ pounds with batteries; dimensions (length) 11 x (width) 6⅝ x (height) 5⅞ inches with cover closed

TYPE 728-A D-C VACUUM-TUBE VOLTMETER $110

At present this instrument is available only for high priority war orders; reservation orders for later deliveries are being accepted.

Write for a copy of the G-R Experimenter for December 1944 for complete description of this instrument.

GENERAL RADIO COMPANY Cambridge 39, Massachusetts
NEW YORK CHICAGO LOS ANGELES

Whatever band the FCC finally assigns

to your broadcast, VHF, UHF or other communications devices, we will always be ready

to produce accurately and deliver on schedule

Control Crystals to your exact specifications.

Meanwhile, may we offer our extensive

experience with the more difficult frequencies,

without obligation, if it can help your planning.

PAN-ELectronic LABoratories, Inc.

500 SPRING STREET, N.W. • ATLANTA, GEORGIA

Pan-El QUANTITY PRODUCERS OF STANDARD AND SPECIAL Control Crystals

tions making master records, and then only when filling such orders as would not interfere with military and OWI requirements.

Workers are scarce to the tune of 10,000 in 153 radar plants which are now behind schedule. Ninety percent of these jobs can be handled by women.

RAILROAD RADIO. Mobile radio equipment allocations and lending for experimental purposes is expected to be controlled by WPB more closely than before. Small quantities of mobile equipment will be granted on a loan basis—usually 90 days—for essential experimentation which would be limited to just a few companies in any one field on the theory that other companies with parallel operations can base their future policy on results of these individual tests.

BROADCAST APPLICATIONS. Under a new policy effective January 16, 1945, FCC announces the following manner of handling applications for new standard broadcast stations or for changes in facilities:

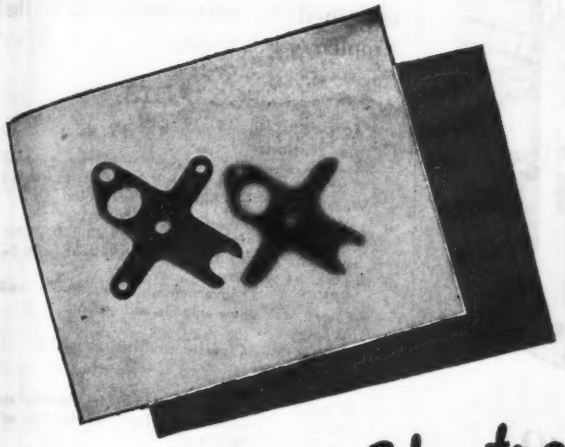
Applications filed before January 26, 1945, and upon which the Commission has taken no action, will be held in status quo unless the applicant files a petition requesting action or unless the Commission itself desires to determine issues which would require hearings regardless of material and manpower.

Applications filed before January 26, 1945, which have been designated for hearing but no hearing has been held, will be retained in status quo unless either of the alternative factors apply as indicated under the former category.

Applications filed before January 26, 1945, in which hearings have begun but the record has not yet been completed, will be finished and held in the pending file unless it appears that a grant can be made under the terms of the Commission's supplemental policy statement of Jan. 26, 1944.

Applications filed before January 26, 1945, and in which hearings have been concluded, will be decided and announced where a grant is possible under terms of the supplemental statement of policy or a denial is necessary regardless of the availability of materials and manpower.

Applications filed after January



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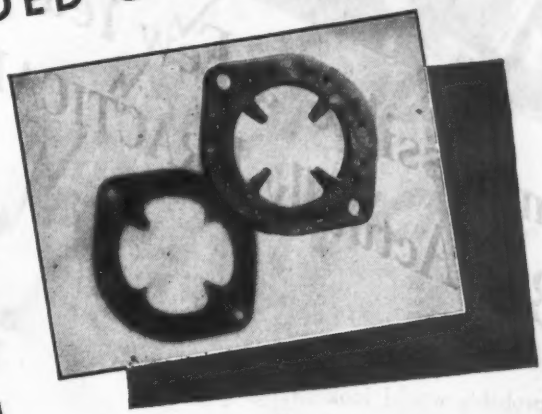
WITH INJECTION MOLDED G-E MYCALEX



G-E Mycalex is doing a big job for the electronic industry. A speedy yet precision type of injection molding developed by the General Electric Company allows intricate shapes to be molded to extremely close tolerances.

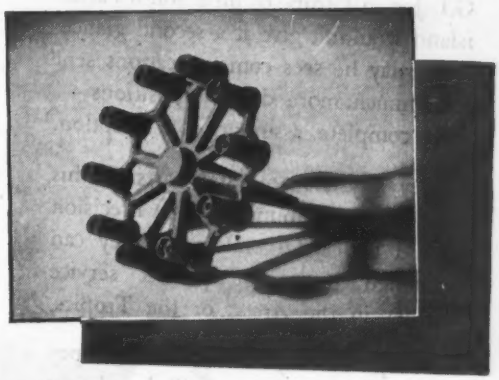
G-E Mycalex can be molded with metal inserts, and as a result, the metal and the G-E mycalex are fused into an unusually strong bond.

Having over-all electrical properties superior to celain products and refractory qualities superior to organic plastics, G-E mycalex remains the all-purpose, high-heat, high-frequency insulation material for use in the radio and electronic industries.

For further information write Section S-51, General Electric Company, One Plastics Avenue, Pittsfield, Mass.

G-E mycalex has the following properties:

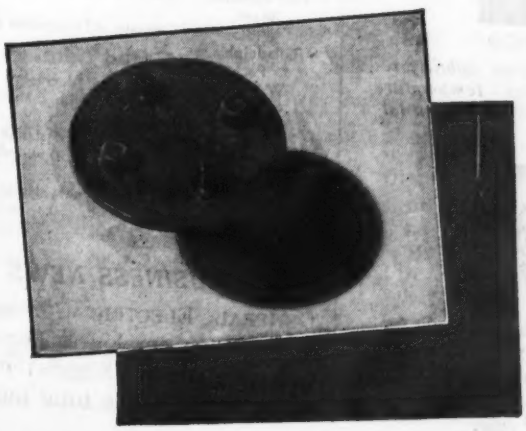
1. High dielectric strength. 2. Low power factor. 3. Prolonged resistance to electric arcs. 4. Chemical stability; no deterioration with age. 5. Dimensional stability; freedom from warpage, shrinkage, etc. 6. Imperviousness to water, oil and gas. 7. Resistance to sudden temperature change. 8. Low co-efficient of thermal expansion.



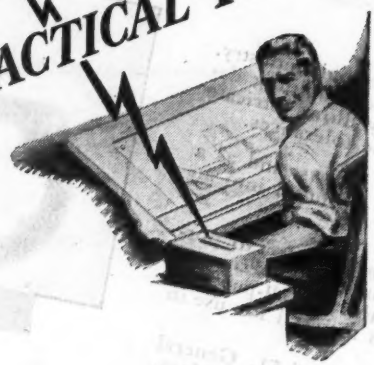
Hear the General Electric radio programs: "The G-E All-Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news every weekday 6:45 P.M. EWT, CBS. "G-E House Party" every weekday 4:00 P.M. EWT, CBS.

Buy War Bonds

GENERAL ELECTRIC PD-51



Impossible a Few Years Ago —But Actually PRACTICAL Today

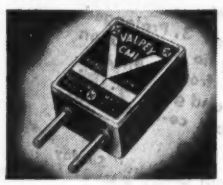


Yes, it probably would look strange to us to see such a sight today. But the G.I. Joe in Europe or on a South Pacific island wouldn't give it a second glance. Every day he sees communications sent from much more difficult positions — with complete assurance of reception.

Valpey Crystals are vital parts of this type of communication. Precision ground by crystal craftsmen, they can be relied upon for perfect service whether in the Arctic or the Tropics.

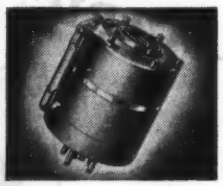
As they did *before* the war Valpey Crystals *after* the war will be chosen for their high fidelity and complete dependability. Peacetime planners are already contacting the Valpey laboratories and are finding Valpey engineers ready to help with any problem of design or performance.

Why not write us for complete information on "Crystionics."



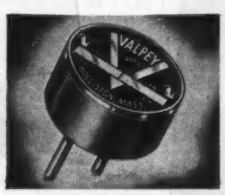
CM-1

A design for normal frequency control applications suitable for marine, aircraft, etc., uses



CBC-0

Where utmost in stability requires constant temperature control in commercial installations



VP-3

Developed for use in mobile equipment and application with limited space.

VALPEY Crystal Corp.

CRAFTSMANSHIP IN CRYSTALS SINCE 1931

HOLLISTON, MASSACHUSETTS

26, 1945 will be processed and determined in accordance with the supplemental policy.

FCC ACTS

To permit this station	To do this:
KPQ Wenatchee Wash.	Change to 560 kc, Up power to 1 kw, Install new transmitter
WSCC Savannah, Ga.	Relay to WTOC on 30,820, 33,740, 35,820, and 37,980 kc with 2-w power
KRKO Everett, Wash.	Move transmitter and studio, install new antenna and ground
KFEQ St. Joseph, Mo.	Operate auxiliary transmitter
W3XO Wash., D. C.	Move transmitter for allocation and coverage studies in conjunction with W3XMB.
KCMO Kansas City, Mo.	Increase power to 5 kw contingent on later move of transmitter to protect KTBS and other points.
Dublin, Ga.	Construct new station on 1340 kc, 250 w unlimited time.
KOIN Portland, Ore.	Make changes in present transmitter equipment.
WJEF Grand Rapids, Mich.	Operate a new station on 1230 kc, 250 w, unlimited time.
KELO Sioux Falls, S. Dak.	Operate with new antenna
WJNO West Palm Beach, Fla.	Move transmitter and studio.
WFBM Indianapolis, Ind.	Construct 1 kw auxiliary transmitter using directional antenna at night.
WNYG New York, N. Y.	Construct new relay broadcast station for 1622, 2058, 2150 and 2790 kc, 40 w.
Rome N. Y.	Construct new standard broadcast station to operate on 1450 kc, 250 w, unlimited time.
WEBC Duluth, Minn.	Change automatic frequency control unit of auxiliary transmitter.
WINS New York, N. Y.	Use former main transmitter as auxiliary of 1-kw power with directional antenna day and night.
WJOD Washington, D. C.	Move relay broadcast transmitter.
WEJC Washington, D. C.	Operate relay station transmitter at new location, move main transmitter, and change antenna.
WAGE Syracuse, N. Y.	Operate auxiliary transmitter with 250-w power using directional antenna at night.
WCHV Charlottesville Va.	Operate at frequency of 1240 kc.
WBKY Lexington, Ky.	Operate new non-commercial educational broadcast station on 42,900 kc, 500 w.
Cambridge, Mass.	Construct developmental broadcast station, frequency to be assigned, 250 w, AO, A4 and special emission for fm, unlimited time.
KONP Port Angeles, Wash.	Operate a new station at 1450 kc, 250 w, unlimited time.
WIBG Philadelphia, Pa.	Operate old transmitter as auxiliary.
WATW Ashland, Wis.	Operate at increased power of 250 w and with change in type of transmitter.
Sacramento, Calif.	Construct a new station to operate on 1490 kc, 250 w, unlimited time.
Sacramento, Calif.	Construct a new station to operate on 1340 kc, 250 w, unlimited time.

BUSINESS NEWS

GENERAL ELECTRIC Co. has paid $232,735 to employees for production-accelerating suggestions made during 1944. The total number of

Incorporate GENERAL PLATE LAMINATED METALS into your Post-War Products

If you want to be sure that your post-war products are out in front in the peace period, do as other manufacturers are doing . . . include General Plate Laminated Metals into your designs. These versatile laminated metals will give you many performance and sales advantages that cannot be obtained with solid metals. For instance, permanently bonded laminations of precious metals to base metals give solid precious metal performance at a fraction of the cost of solid precious metals. In addition, the precious metals provide better electrical conductivity or corrosion resistance and long wearing life. The base metals permit workability, ease of fabrication and strength. Don't be caught off guard in the coming sales battle, incorporate General Plate Laminated Metals into your products now. They are available in raw stock, sheet, wire or tube . . . inlaid or wholly covered or as completely fabricated assemblies. Our engineers will gladly give you every assistance in the selection of the right metal combination for your particular products. Write for their services, today.

General Plate Division OF METALS & CONTROLS CORPORATION

50 Church St., New York, N. Y.; 205 W. Wacker Drive, Chicago, Ill.; 2635 Page Drive, Altadena, California; Grant Bldg., Rm. 603, Pittsburgh, Pa.

ATTLEBORO, MASSACHUSETTS

ACCURACY CANNOT BE COMPROMISED WITH IN THESE WAR DAYS OF LIGHTNING SPEEDS AND WORLD WIDE COMMUNICATIONS, ALL TUNED INTO OUR PRESENT TEMPO BY PRECISION GEARS.

Quaker City Gear Works
INCORPORATED
1910-32 North Front Street, Philadelphia, Pennsylvania

ideas paid for was 19,488 and the record award was $2,000.

COLUMBIA BROADCASTING SYSTEM is giving a 60-week course in the operation of television studio and transmitter equipment to 175 of the network's technical employees. Divided into three sections of 20 weeks each, the course is being given by the division of general education and College of Engineering, New York University.

HYTRON CORP., Salem, Mass., has changed its name to Hytron Radio & Electronics Corp.

MCMURDO SILVER CO. is a new engineering and manufacturing concern established in Hartford, Conn. Activities will involve amateur parts, kits, and special equipment production as well as consulting engineering.

ALLEN B. DUMONT LABORATORIES, INC. has an order for the first television transmitter to be installed in Australia. The projected location is Sydney, N. S. W.

PHILHARMONIC RADIO CORP., a subsidiary of American Type Founders Inc. has been consolidated with the ATF remote control division, both at New York, N. Y. Home radio plans are being dropped.

OHMITE MFG. CO. makes an initial grant of $15,000 to Illinois Institute of Technology for establishment of a laboratory there. Activities will involve precision measurement of electrical and magnetic quantities with an ultimate goal of approaching the accuracy of the Bureau of Standards, Washington, D. C.

SONOTONE RESEARCH LABORATORIES, Elmsford, N. Y., has met the manpower shortage by the employment of large numbers of school girls from the bobby sox crowd of Westchester County.

WESTINGHOUSE ELECTRIC INTERNATIONAL CO., East Pittsburgh, Pa. is planning a Portuguese edition of *El Ingeniero Westinghouse*, the Spanish technical magazine produced for Latin America.

PHILCO CORP., Philadelphia, Pa. takes over the facilities formerly occupied by Hunter Mfg. Co. at Croydon, Pa. Utilizing approximately 200 employees, the new facil-

★ ★ ★

What's all this talk about "SMALL BUSINESS"?

There's no "small business" anymore. From now on, the main issue in this country will be *National Security* . . . and in this sense there are no more small businesses.

They are ALL Component Parts of BIG BUSINESS

National Security will increasingly come to mean spreading more and more business over more and more areas . . . with more and more qualified sub-contractors . . . thus making every community self-supporting . . . providing full employment . . . equalizing in the truest sense the distribution of our national wealth.

Business is no different from an army. The success of both depends upon the efficient integration of its component units . . . and no one unit is expected to do the entire job.

That's the lesson we've learned from the war. And the more we apply it expertly and unselfishly to our industrial problems of production, the sooner we will resolve most of the disturbing conditions that hitherto have continued to upset our economic balance.

Handling 5000 Contracts in One Year

Here at Lewyt, during 1944, we produced a great variety of component parts and assemblies of important war equipment . . . complicated electronic mechanisms that involved the use of many highly specialized skills. We successfully met the most exacting requirements of low-reject production and frictionless synchronization with other manufacturers' schedules. Our year's activities summed up to filling *5000 separate contracts for other manufacturers!*

Few plants make their entire product anymore. We have become a nation of sub-contractors. Sub-contracting has emerged from pre-war obscurity to occupy a place of dignity and ever-increasing stature in our future economy.

★ ★ ★

Write on your business stationery for 48-page book, "Let Lewyt Do It"—the story of the Lewyt organization in pictures. Lewyt Corporation, 60 Broadway, Brooklyn 11, N. Y.

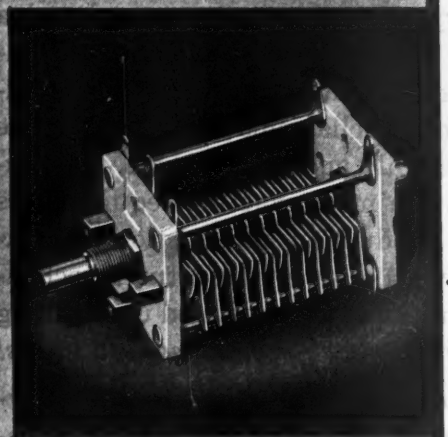
ARMY E NAVY

Lewyt

A CONTRACT MANUFACTURER—EXPERTLY STAFFED TO PRODUCE COMPLETE ELECTRONIC AND MECHANICAL ASSEMBLIES, COMPONENT PARTS AND SUB-ASSEMBLIES, TO THE MOST EXACTING REQUIREMENTS

CONTINUE ☆ BUYING ☆ WAR ☆ BONDS

Designed for Application



The 23000 Series
Variable Air Capacitors

"Designed for Application," double bearings, steatite end plates, cadmium or silver plated brass plates. Single or double section. .020" or .060" air gap. End plate size: 1 1/16 x 1 1/2. Rotor plate radius: 19/32". Shaft lock, rear shaft extension, special mounting brackets, etc., to meet your requirements.

JAMES MILLEN MFG. CO., INC.

MAIN OFFICE AND FACTORY
MALDEN
MASSACHUSETTS

ities will specialize in the export packing of spare parts for radio and electronic equipment.

E. I. DU PONT DE NEMOURS & CO. establishes an electronics group in its rayon department. Much of the activity of the group will be concerned with development of methods for control of various operations.

HALLICRAFTERS CO., Chicago, Ill. announces an employee profit-sharing trust plan for workers with three years seniority. All payments to the fund will be made by the company.

TECKNA CO. is the new name of the plastic-fabricating and product engineering concern formerly known as Teckna Plastic Co. The company is located in Bayside, L. I., N. Y.

UNIVERSITY OF LOUISVILLE establishes a non-profit Institute of Industrial Research whose purpose is to engage in engineering and scientific research for industrial and private clients on a contract basis.

ELECTRONIC TESTING LABORATORIES INC., Newark, N. J. has completed a program for expansion of its production facilities.

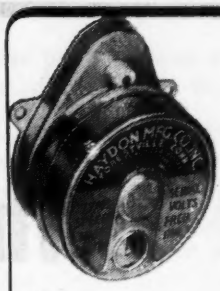
ADAPTOL CO. is now located in enlarged quarters at 260 Utica Ave., Brooklyn, N. Y.

JAMES KNIGHTS CO., Sandwich, Ill., has effected a license agreement with Western Electric Co. and will manufacture electronic equipment under their patents.

SOUND APPARATUS CO. announces the location of new offices in the Woolworth Bldg. at 233 Broadway, New York 7, N. Y.

PERSONNEL

FRANK P. BARNES, former instructor in electronic and radio engineering at the University of Washington and with General Electric Co. since 1937, is appointed district representative of the transmitter division of the company's elec-



Let Haydon*
Electroneered Timing

HANDLE YOUR PROBLEM

Wherever mechanical equipment can be regulated by automatic timing, Haydon Electroneered Timing — with its many types of synchronous timing motors available — will fit your product and the new automatically controlled devices of the future.

Synchronous AC timing motors by Haydon, are available with torque output of 5 to 20 inch ounces, basis 1 RPM; specially protected, where necessary, for salt spray, tropical service, vibration or shock; lubricated to ambient temperature specifications of the customer; special coils and leads available for high temperatures; available in a wide range of voltages, frequencies, and output shaft speeds. Compact — light in weight — rugged and reliable.

Write today for your copy of this catalogue.

*ELECTRONEERED TIMING
Haydon
MANUFACTURING COMPANY
INCORPORATED
Forestville, Connecticut
Manufacturers of the broadest range of timing motors

Hermetically Sealed TRANSFORMERS

Illustrated at left is a Langevin Hermi-Lock hermetically sealed transformer. Case must be destroyed before interior of unit can be reached. Hermi-Lock provides extensive safety factor for combat use.

The failure of a hermetically sealed transformer is largely due to the fact that solder is depended upon for a mechanical union as well as the hermetic seal. Solder having a low tensile strength is readily fractured by thermal action, vibration or shock, and the seal broken; with failure a probability.

LANGEVIN hermetically sealed transformers employ the unique *Hermi-Lock construction which provides a positive mechanical union between body, cover and bottom, the solder being simply the sealing agent. The result is a dependable unit with little chance of failure under simultaneously adverse conditions.

Your inquiry for transformers of all types up to 5 KVA are solicited.

*Trade Mark Registered

−50°C AMBIENT

+65°C AMBIENT

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

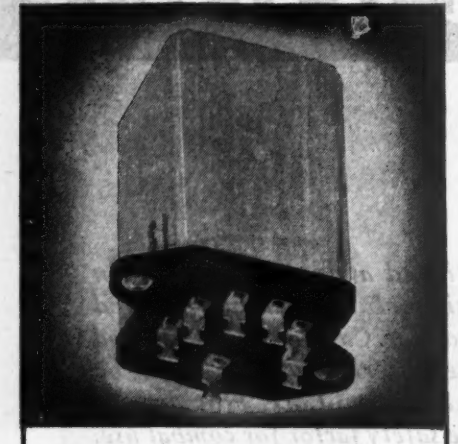
NEW YORK
37 W. 65 St., 23

SAN FRANCISCO
1050 Howard St., 3

LOS ANGELES
1000 N. Seward St. 38

Co-ordination

A NEW ROLE FOR SIGMA RELAYS



The 5 RPL relay has two coils with separate terminals which may be connected to independent pilot circuits. The load of the relay is operated only by the co-ordination of the two pilot circuits. This may be the sum or the difference of the pilot circuit voltages depending on the polarity of coil connections.

The same result can be accomplished with the unmounted type 5 F relay but the enclosed form is usually preferred. Both types are widely used in aircraft applications where circuit co-ordination is desired.

SIGMA

Sigma Instruments, INC.

Sensitive **RELAYS**

62 Ceylon St., Boston 21, Mass.

tronics department. His headquarters will be in San Francisco.

WILBUR L. NELSON is made mechanical design engineer of The

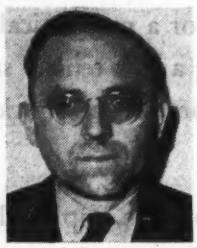
Andrew Co., Chicago, Ill. Mr. Nelson has been with Western Electric Co.

ARDEN LEFEVRE, formerly divisional chief engineer of Stewart-Warner Corp., is appointed vice president and director of engineering of the division including instruments and radio.

DAVID C. PRINCE, vice president, General Electric Co., takes charge of the company's general engineering laboratory. Laboratory activities are being broadened to include the requirements of the entire company.

GEORGE W. OEHLSEN, JR., formerly assistant chief engineer of the radio division, becomes assistant director of engineering in Division One (instruments and radio), Stewart-Warner Corp., Chicago, Ill.

WALTER R. JONES is appointed to the newly created post of general engineering manager for radio re-



ceiving tubes by Sylvania Electric Products, Inc. Previously manager of commercial engineering, Mr. Jones has headquarters in Emporium, Pa.

KENNETH S. LUM, previously with Measurements Corp., becomes assistant chief engineer at Madison Electrical Products Corp., Madison, N. J.

F. A. HITER, senior vice president, Stewart-Warner Corp. is elected to the board of directors of RMA to

NEW GUIDE TO PRECISION-MADE PLASTICS

By Sillcocks-Miller

FREE BOOKLET PRESENTS 4 - POINT SERVICE TO HELP DESIGN ENGINEERS

How the facilities and experience of Sillcocks-Miller specialists can help you solve your problems in precision-fabricated plastics is told in a new illustrated booklet now available.

Designers and manufacturers in need of plastic parts and products made to extremely close tolerances will find the Sillcocks-Miller Company a most dependable source for design and development service and for highest quality production.

Whether you are now using plastics or want to learn why it will pay you to convert to plastics, you should have a copy of this helpful booklet. Write for it today — without obligation.

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It Costs You Less to Pay a Little More for Sillcocks-Miller Quality

400 MICRO-MICRO WATTS (.000000000400 WATTS!)*

This figure represents the maximum limit of power radiated by the oscillator in Techrad's LRR-5 receiver!

Designed originally for use on ships operating in the combat zones, the LRR-5 low radiation receiver offers definite advantages to other services.

1. For monitoring or standby where a number of receivers are operated in close proximity.
2. For dual or triple diversity reception.

Low radiation has been accomplished in the LRR-5 receiver without compromise in electrical performance.

1. Radiation less than 400×10^{-12} watts throughout the entire range.
2. Signal-to-noise ratio at 15 micro volts is 20 db.
3. 10 watts audio output at 3% total harmonic distortion.
4. 50 to 15,000 cycle audio frequency response ±1 db.
5. Variable selectivity.
6. Beat oscillator.
7. Coverage: 540-1600, 2.6-6.3, 6.3-18 mc.

F C C approved

Your receiver problems will receive prompt and thoughtful attention when you consult our engineers. Write now for complete information and data.

technical radio company

275 NINTH STREET • SAN FRANCISCO 3, CALIFORNIA

EXPORT AGENTS: FRAZAR & HANSEN, 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA, U. S. A.

Over a decade of continuous experience

Silent operation of postwar appliances and electrical equipment will require Pilot Light assurance of "ON" and the added advantage of the animated eye appeal of light. Gothard's broad line of Pilot Light Assemblies —developed thru both war and peacetime research— will provide the solution to that need. Beyond the scope of this broad line—Gothard engineers offer you a wealth of Pilot Light experience to satisfy special requirements. Consult Gothard on your present and postwar plans.

Gothard
MANUFACTURING COMPANY
1310 N. Ninth St. Springfield, Ill.
Export Div.
New York 17, N. Y. 25 Warren Street
Cables
Simontrice, New York

Model 1216
takes NE45 Neon Lamp
also available for NE48 and NE51 Neon Lamps

AMPERITE

THERMOSTATIC METAL TYPE
DELAY RELAYS
PROVIDE DELAYS RANGING FROM 1 TO 120 SECONDS

Other important features include:—

1. Compensated for ambient temperature changes from —40° to 110°F.
2. Contact ratings up to 115V-10a AC.
3. Hermetically sealed — not affected by altitude, moisture or other climate changes . . . Explosion-proof.
4. Octal radio base for easy replacement.
5. Compact, light, rugged, inexpensive.
6. Circuits available: SPST Normally Open; SPST Normally Closed.

WHAT'S YOUR PROBLEM? Send for "Special Problem Sheet" and Descriptive Bulletin.

with porcelain heater

with heater wound directly on blade

AMPERITE CO. 561 BROADWAY NEW YORK 12, N. Y.
In Canada: Atlas Radio Corp., Ltd.
560 King St. W., Toronto

replace L. L. Kelsey, formerly with Stewart-Warner Corp. and now with the Belmont Radio Corp., Chicago, Ill.

CAMERON G. PIERCE, who has been active in radar development is district representative for Southern

California and Arizona in the transmitter division of General Electric Co.'s electronics department.

F. C. ALEXANDER joins Mackay Radio Telegraph Corp. to become executive assistant to the vice president and chief engineer. He has been in the office of the Director of Naval Communications.

AWARDS

Workers of the following concerns in the electronic field have been awarded Army-Navy burgees for excellence in production:

Belden Mfg. Co.
Chicago, Ill.
Richmond, Ind.

David Bogen Co.
New York, N. Y.

Dobeckmun Co.
Cleveland, Ohio

General Cable Corp.
Buffalo, N. Y.
St. Louis, Mo.

Muter Co.
Chicago, Ill.

National Carbon Co.
Charlotte, N. C.

Northern Radio Corp.
Seattle, Wash.

Ohio Crankshaft Co.
Cleveland, Ohio

Roller-Smith Div.
Realty and Industrial Corp.
Bethlehem, Pa.

Santay Corp.
Chicago, Ill.

Westinghouse Electric & Mfg.
Sunbury, Pa.

WHY WE MEASURE OUR OWN "YARDSTICKS"

Complex, sensitive instruments are a commonplace not only in the engineering laboratories but on the production lines of Connecticut Telephone & Electric Division. These instruments enable us to maintain the extreme precision in telephone equipment and electronic devices called for by Signal Corps standards. So important is this high precision that we have special apparatus for measuring the accuracy of the test instruments themselves.

The result of this constant testing and retesting is *better products*... better telephones, headsets, switchboards and other devices, for our armed forces, a better, brighter future for your communicating systems, electrical and electronic equipment for tomorrow.

MEASUREMENT BY TIME SIGNALS... *Using U. S. Government radio time signals of infinite accuracy as a basis, this apparatus permits our engineers to "test our own test instruments" for the ultimate in engineering and production-line accuracy.*

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES, INC. • MERIDEN, CONNECTICUT

TELEPHONIC SYSTEMS • SIGNALLING EQUIPMENT • ELECTRICAL EQUIPMENT • HOSPITAL AND SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS • IGNITION SYSTEMS

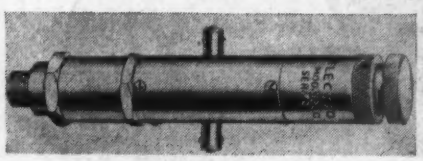
NEW PRODUCTS

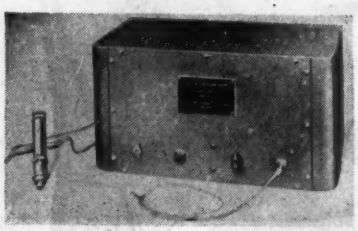
Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Pressure-Time-Curve Indicator

PRESSUREGRAPH is an electronic device which will indicate, in linear response on the screen of a cathode-ray oscillograph, the pressure-time curve of any internal combustion engine, pump, airline, or any other enclosed pressure system where pressure measurements are desired. It measures either static or dynamic pressures. It is easy to operate because only one control is necessary, and one initial adjustment to compensate temperature effects need be made.

Electro Products Laboratories, 549 West Randolph St., Chicago 6, Ill.





Top illustration shows pick-up section of Pressuregraph. Pickup response is transmitted, after amplification, to the screen of a cathode-ray oscillograph. Illustration below shows pickup hooked up to unit

Recording Unit

RADIOTONE is the name applied to recording equipment (for schools, plants or studios) made by the Robinson-Houchin Optical Co., Columbus, Ohio. The new console model illustrated incorporates features of the manufacturer's RA-16 portable Radiotone, except that it also has an acoustic cabinet. The console consists of a recording cutter (which records speech directly or from the unit's own built-in radio); playback (instantaneous); and a PA system. The recorder operates at speeds of 78 or 33⅓ rpm, and cuts from inside or outside. The high-fidelity cutting head maintains its adjustment and has a uniform frequency response from 40 to 6000 kc. The ball-bearing, playback arm is counterbalanced, and uses a magnetic needle. Frequency range is from 30 to 7000 cps.

Above, the new console model described above. Below, shows Radiotone recording equipment installed at the Jack & Heintz Co., plant in Cleveland, Ohio

Other features of the equipment include: two equalizers used to vary the low-frequency response. One equalizer operates at about 100 cycles from 1 to 15 db above or below normal. The other gives constantly variable boost at around 7500 cps of from 1 to 22 db, or an attenuation of from 1 to 15 db below 5000 cps; two dual high impedance channels are provided with two separate jacks. One jack includes a preamplifier and gives an over-all gain of 115 db. The other jack skips the preamplifier tube and lowers the gain to 80 db; two volume controls, which can be operated simultaneously, and which regulate the input signal from two microphones, microphones and dubbing table, tuner and microphones, or tuner and dubbing table. One channel has a gain of 80 db and the other a gain of 115 db.

The equipment is easy to operate since all functions are regulated instantly by depressing one or more of seven different buttons.

Circuit Breaker

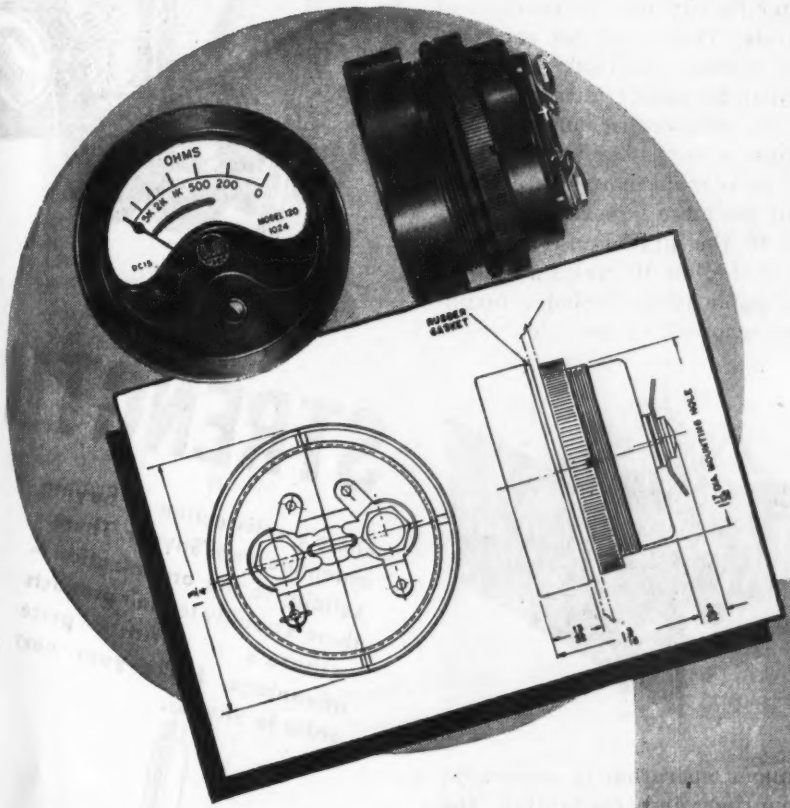
NOW IN PRODUCTION is a new and improved single-pole circuit breaker for 240 volts ac or 125 volts dc, 50 amp maximum which can be front or rear connected. Breakers have

instantaneous trip or a selection of three time delays. Overall dimensions are 5¼-in. long, 2¹³⁄₁₆-in. high, and 1½-in. wide.

Heinemann Circuit Breaker Co., 97 Plum St., Trenton, N. J.

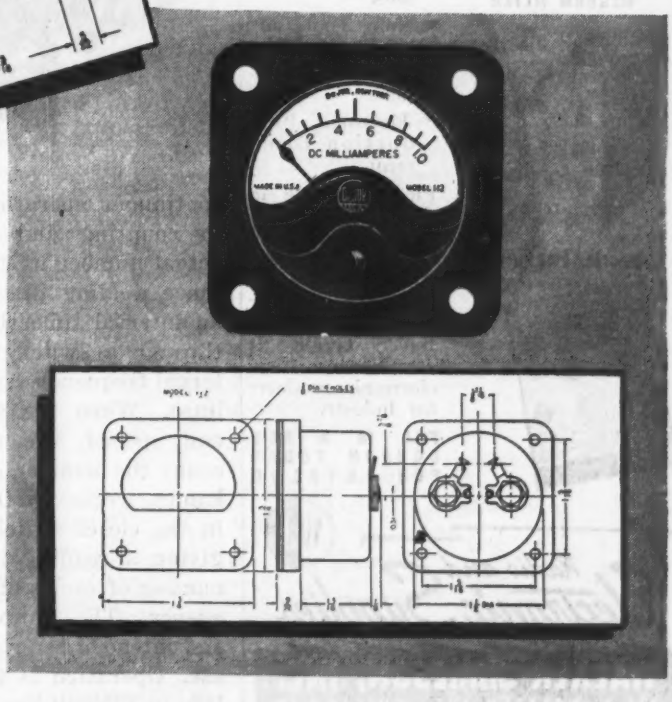
DeJUR HERMETICALLY SEALED MINIATURE 1½" METERS

Designed to aid in the development of small equipment for present or postwar applications



1½ INCH ROUND MODEL 120

The smallest meter of its kind, built with the care and precision of all DeJur larger instruments. Sealed to sustain immersion in 30 feet of water for as many as 7 days without harm to the mechanism. If the glass breaks, the meter case is designed to seal the equipment against water seepage. Terminal studs are also waterproof sealed. Another advanced construction feature is the ring mounting which makes for quick and easy installation—no mounting holes or screws necessary, just tighten on with the ring. A.S.A. type movement. Built to exacting specifications.



1½ INCH SQUARE MODEL 112

Entirely self-contained with built-in resistors and shunts. Available in wide variety of ranges. This model, too, may be immersed in 30 feet of water for 7 days without harm to the movement. In addition, it incorporates all other waterproof features of the Model 120. Though compact in size, no sacrifice has been made in quality of materials or construction details. It performs with high efficiency in a variety of applications. A.S.A. type movement. Built to exacting specifications.

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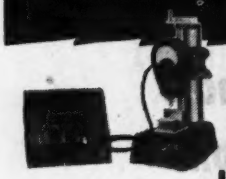

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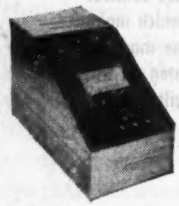
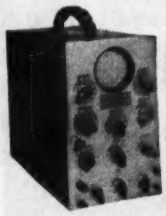


MEGOHM METER



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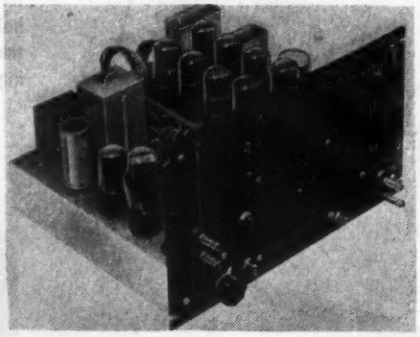
Electronic Counter

A NEW TWO-DECADE counter, designed for industrial and laboratory uses, is actuated by a closing contact, sine wave, or pulse input (as from a photocell) at rates up to 1000 cps. Each decade divides by ten, giving a factor of 100. The count for 0 to 99 appears on two banks of neon lamps. A telephone-type relay is connected to the counter output and the contacts of this relay close once for each 100 input cycles. Contacts are connected to an output terminal. Conventional electro-mechanical counters may be connected to extend the count to as many places as desired. One of the more important applications of the unit is in counting rates exceeding 10 cycles a second. Other applications include: installations where long and high speed



continuous operation is necessary; in counting and calibrating the actual number of cycles that resistance welding timers apply; or as an interval timer by connecting it through a switch to a known external frequency (such as a 60-cycle line). When the switch is closed and opened, the instrument will count the number of cycles of the known frequency that have passed in the closed-switch time interval, giving a reading in terms of the number of cycles of the known frequency. The equipment is sturdy and intended for rigorous and long use. Operation is from a 60-cycle, 105- to 125-volt line. Weight of the unit is 25 lb.

Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.

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TYPE 3B27 is a high voltage rectifier tube of rugged construction

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An instrument that can be used as a counter, timer, interval controller, radiation counter, and for many other applications.

This new high speed counter eliminates many of the handicaps of commonly used counting methods. Operating at speeds up to 1000 cycles a second, each decade divides by 10, giving a scaling factor of 100. A telephone-type relay, whose contacts close once for each 100 input cycles, is connected to output terminals. An electro-magnetic counter may be added to this output to extend the count to as many places as desired. The Two-Decade Electronic Counter is useful for counting rates exceeding 10 cycles a second, generally too fast for conventional counters. It may also be used to replace conventional counters that may not stand up under continuous high speed operation. Another use for this instrument is counting and calibration of cycles in resistance welding operations. It may also be used as an interval timer by connecting it through a switch to a known external frequency. Readings are observed in terms of the number of cycles of the known input frequency. The unit can be supplied with switches making it predetermining and useful in control applications.

The Two-Decade Electronic Counter operates from a 60 cycle, 105 to 125 volt line. It uses 11 tubes.

Other counter products are—COUNTER CHRONOGRAPHS for measuring projectile velocities to accuracies of one part in 10,000; **PRECISION TACHOMETERS** that measure engine r.p.m. to a fraction of a revolution; **INTERVAL GENERATORS** that generate a predetermined time interval from 10 microseconds to 10 seconds in 999,999 steps of 10 microseconds; **RADIATION COUNTERS** which resolve repetition rates of well over 0.5 microseconds.

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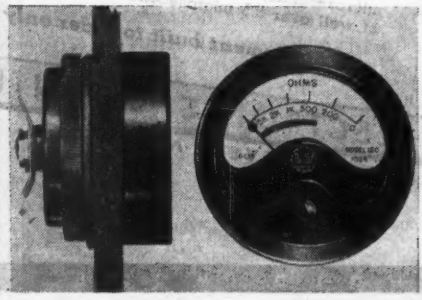
and suitable for industrial and mobile transmitter use. The tube is a high vacuum type. Ratings are: Peak inverse voltage 8,500; peak plate current 0.6 amp; average plate current 0.150 amp; filament draws 5.0 amp at 2.5 volts; four tubes in full bridge deliver 5415 d-c volts to a filter with 6000 volts total input; base is medium 4-pin bayonet type. Electronic Enterprises, Inc., 65-67 Seventh Ave., Newark 4, N. J.

Method of Silver-Coating Quartz Crystals

THIS NEW PROCESS is patented and is available to quartz crystal manufacturers for use in their own plants under license agreements. It is a method of applying a thin conductive silver coating to quartz crystals. The coating is applied simply by dipping the crystals in a series of solutions. It is easy to do and can be done by inexperienced operators. The only equipment required is a few photographer's trays, and clips to hold the crystals. Several hundred crystals may be coated simultaneously. Write Metaplast Co., 205 West 19 St., New York 11, N. Y.

Hermetically-Sealed Meter

TO MEASURE resistance there is available a hermetically-sealed, ring-mounted meter (Model 120) which is built to ASA specifications and which measures 1½ in. The manufacturer states the meter can be immersed in 30-ft of water for as many as 7 days without damage to its mechanism. Terminal studs



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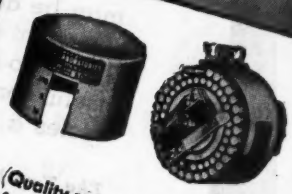

(Quality manufacturers of attenuators and other electrical resistance instruments. For complete data write for Bulletin No. 431.

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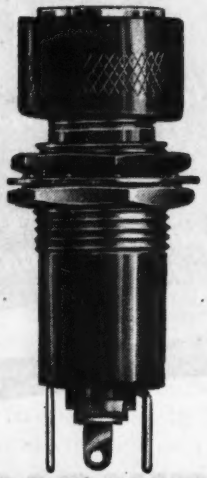

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are waterproofed and therefore the equipment remains waterproof even if the glass is broken. The unit is available in a wide variety of ranges (including microammeter or microvoltmeter specifications), for mounting on any thickness panel between ⅛ and ¼ in, steel or bakelite.

DeJur-Amsco Corp., Northern Blvd. and 45 St., Long Island City, N. Y.

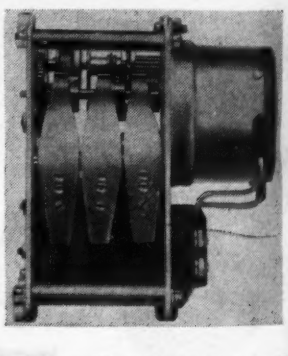
Plating Process and Machine

RECENTLY ANNOUNCED is the development of a new process and machine for high-speed plating of silver and gold on radar wire and parts with uniform specification deposits. The machine for handling wire can take wire measuring 0.0025 in. up to light cable, and is not limited to gold and silver but can handle any plateable metal. Patents have been applied for.

Inquiries should be directed to Joseph B. Kushner, Metal Finishing Engineer, 233 West 26th St., New York 1, N. Y.

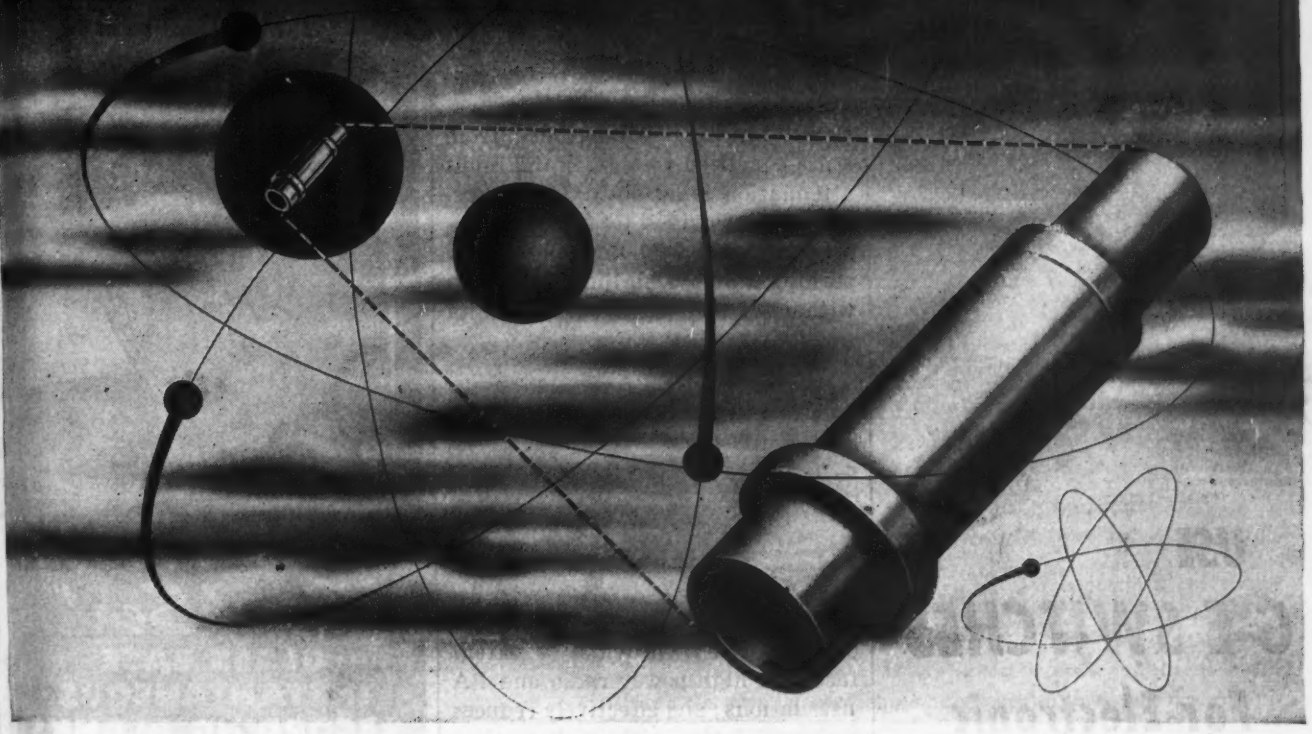
Time Delay Relays

ALTHOUGH ORIGINALLY designed for airborne transmitter equipment, these Type MCR, motor-operated, time delay relays are available for



industrial applications for both a-c and d-c operations. Overall dimensions are approximately 2⅞ x 3⅛ x 3⅞ in. Maximum time ranges are 25 or 50 sec, 2.5, 5.0, or 10.0 min. Minimum time settings are 1.25, 2.5, 7.5, 15.0 or 30.0 sec. Switching units are fully enclosed SPDT with quick, double-make, double-break contacts rated at 10 amp on either 24-volt dc, or 110-volt ac. One switch unit is used to provide an independent load circuit, the second switch is used for the motor con-

SCOVILL PLUGGED A NEW TECHNIQUE INTO RADIO TERMINAL JACKS



. . . and disconnected a tie-up

Terminal jacks for war-needed radios — screw-machined from rod stock — were lagging behind other parts. Expediters called on Scovill to break the bottleneck.

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You can obtain more specific information by writing to Section Q555-119, Appliance and Merchandise Dept., General Electric Company, Bridgeport, Conn.

★ ★ ★

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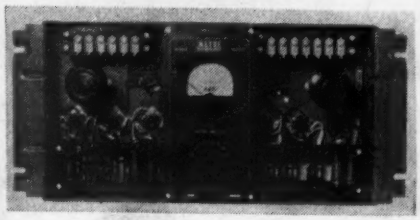
GENERAL ELECTRIC

trol and is set to cut out the motor circuit at the end of the shaft travel. A third switch for a second load circuit can be provided. Motors are permanent-magnet types.

Bulletin No. 3100 describes these units. The R. W. Cramer Co., Inc., Centerbrook, Conn.

Limiting Amplifier

A 70-DB GAIN limiter amplifier eliminates thumping and monkey chatter in radio broadcasting and other sound-reproduction applications. Limiting is controlled from a pre-equalized voltage. Total input attenuation is 30 db in 1 db steps. The unit provides ten to one compression beyond the limiting points; permits a 5 to 6 db limiting action without being apparent; permits



limiting of up to 15 to 20 db without distortion; provides a safety factor in high-power radio and PA nstallations; and effectively reduces over-modulation without distortion. Frequency characteristic rating is plus or minus 1 db over a range of from 20 to 20,000 cycles. The unit is for relay-rack mounting.

Altec Lansing Corp., 1210 Taft Bldg., Hollywood 28, Calif.

Instrument Knob

FOR COMMUNICATION equipment there is available a knob constructed of smooth-finished bakelite with pointer arrow on front. It comes

complete with a ¼-in brass insert and set screw. It measures 1¾ over-all diameter, and ⅞-in over-all height. List price 35 cents each. General Cement Mfg. Co., Rockford, Ill.

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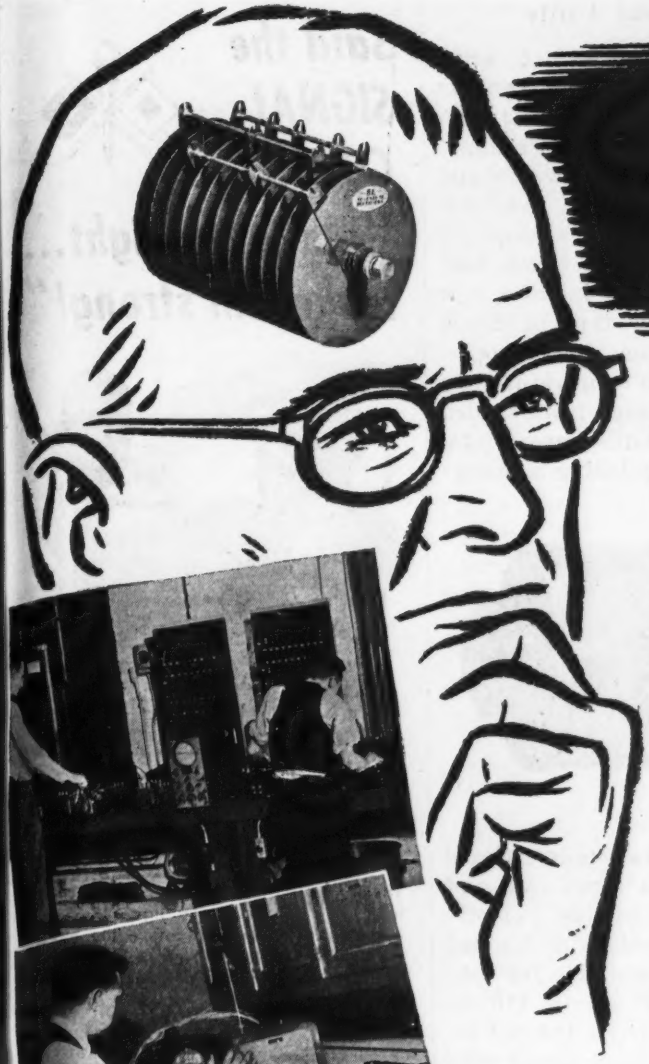

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The ideas that will permit the successful development of your electrical equipment requiring the use of metallic rectifiers have perhaps already been developed by B-L engineers.

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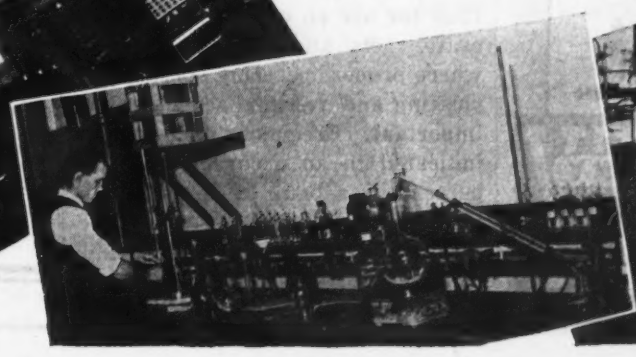

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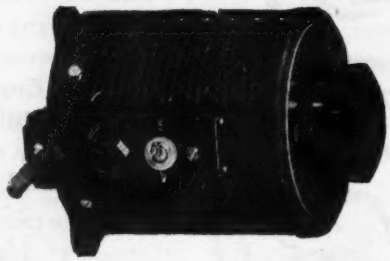
Voltage Control Units

FOR VOLTAGE CONTROL of small power applications, Powerstats (No. 116 and No. 216) have been added to this manufacturer's standard line of compact, lightweight and ruggedly constructed variable transformers in the 1-kva range. An extra large aluminum brush heat radiator is combined in these new units with a new type of brush pressure adjustment spring to assure a small brush temperature rise and to lessen damage from sudden overloads. Both units have a total weight of 9 lb, including a protective screening and a totally-enclosed terminal box with input cord and plug, an outlet, and an "on-off" switch. Uncased models (designated as U types) are available for rear panel mounting. Powerstat 116 operates on a single phase 115-volt input to deliver a variable output voltage from zero to 135 volts with 7.5 amp available at any brush position. Model 216 has twice the voltage rating and a current rating of 3.0 amp. By mounting single units in tandem, different voltage and current ratings can be obtained. Circuit diagrams are contained in Bulletin No. 116 available from Superior Electric Co., Bristol, Conn.



Indicating Instrument

A NEW FREQUENCY meter and elapsed time meter comes in one case to save panel space and weight. It is for use on engine-driven generator sets and other equipment where proper operating speeds, lubricating and overhaul schedules are important. Frequency or speed is indicated to an accuracy of ±0.3 percent by a bank of 5 reeds calibrated in single cycle steps from 58 to 62 cycles. The running time meter is driven by a synchronous motor, and indicates elapsed time

Said the SIGNAL CORPS... "Make 'em light... make 'em strong!"

SKYDYNE CABINETS for Portable Electronic Equipment

They're as rugged as the combat corpsmen they serve—yet so light, they add only ounces to the delicate radio equipment they protect! And these famous Skydyne cabinets, serving overseas with the U. S. Signal Corps, are now available for your electronic products.

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Skydyne combines *greater strength* with *less weight* than any other instrument-housing material. Form-molded to exact specifications, Skydyne is laminated on a balsa, cork or lightweight synthetic core —faced with plywood, metal or other surfacing material. Modern electronic shielding is incorporated in the cabinet itself. Complex shapes and curvatures are possible without complicated design, production or assembly problems. Skydyne assures an attractively streamlined one-piece cabinet that stands up to rough handling, resists heat, vibration, sound. And Skydyne is remarkably inexpensive.

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The new Telechron C-40 electric radio switch clock will be available for panel mounting, with dial and hands styled to your special needs. Telechron accuracy, long life and dependability give you extra selling points. For full details, write or wire Industrial Sales Division, Dept. K, Warren Telechron Company, Ashland, Mass.

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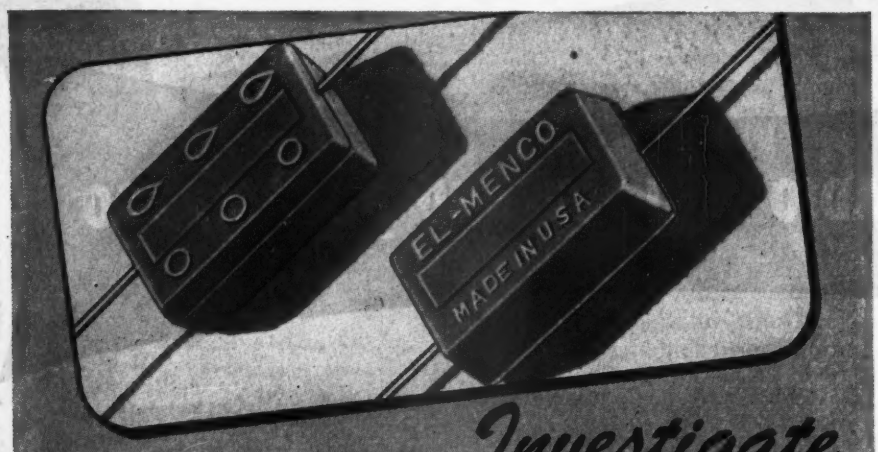

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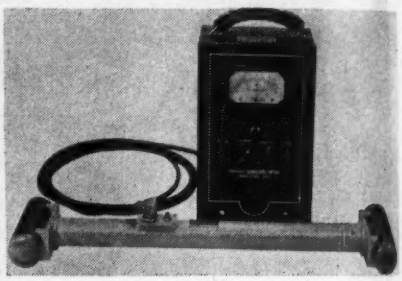
- [illegible]

in hours and tenths. Designated as Model 31-FE, this meter operates on 110 volts, and is also available for 48 to 52 cycles and in half cycle steps for 59 to 61 cycles and 49 to 51 cycles, with accuracy of ±0.2 percent. Other ranges are under development.

J-B-T Instruments, Inc., New Haven, Conn.

Indicating Unit

ILLUSTRATED is an indicating unit, designated as Gradientometer, which quickly locates magnetic fields as in aircraft inspection, lost tools, underground piping, in searching for conduits, etc. The unit differs from the manufacturer's Magnetometer because it



requires no leveling. It cancels out uniform magnetic fields, such as the earth's field, and is designed primarily to locate magnetic gradients. By pressing a button it is converted into a Magnetometer and may be used to measure the strength of magnetic fields.

Waugh Laboratories, 420 Lexington Ave., New York 17, N. Y.

Gas Purifiers

THREE PALLADIUM catalyst chambers known as Duexo gas purifiers have been used successfully by the Vacuum Tube Div. of Federal Telephone & Radio Corp. (Clifton, N. J.) to remove hydrogen from nitrogen and to remove oxygen from hydrogen as part of a test of the new units developed by Baker & Company as a means to reduce costs and to save time in plants requiring pure gases.

Relays

WEIGHING 1¾ oz, Type 23000 signal and communication relays (meeting Signal Corps requirements for humidity, salt spray, and fungus) are

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Today, Rubber Mountings are a vital structural element in virtually all military electronic equipment. They have also been incorporated into the design of many wartime vehicles and heavy weapons.

Production of U.S. Rubber Mountings is still entirely devoted—directly or indirectly—to the war effort. *So numerous and exacting are current demands on United States Rubber Company technicians in this field that work on problems of vibration-elimination for postwar products must be indefinitely postponed.*

We deeply appreciate the patience and understanding our manufacturer-customers are showing in this situation. And we look forward eagerly to the time when we can again work with them in close cooperation.

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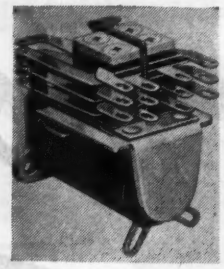
for use in airborn radio transmitters or for applications requiring relays that withstand vibration, humidity and temperature ex-

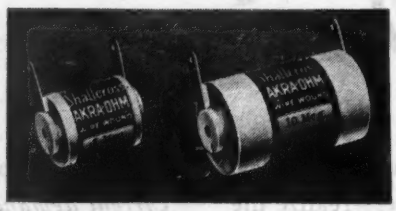


tremes. Units are available with 6 normally open contacts or in arrangements of normally open and normally closed contacts. Contacts are rated 3 amp, d-c non-inductive. The magnet coil bobbin is of a high-impact type. These relays are also available with heavy duty contacts rated at 10 amp, 28 volts d-c non-inductive.

R-B-M Mfg. Co., Logansport, Ind.

Hermetically-Sealed Resistors

No. 1100 SERIES is a new type of hermetically-sealed, accurate-fixed, wire-wound resistor impervious to moisture, fungus, vibration, and rough handling. They are constructed without glass, or stud-

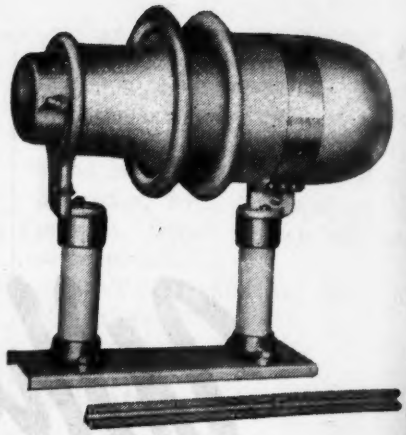


locked resistance elements, ferrule terminals or caps. The Series is available in two designs and in all resistance values from 1000 ohms to 10 megohms.

Shallcross Mfg. Co., Collingdale, Pa.

Evaporator

NOT ALL THE possible applications of Model C evaporator have been explored, but one application in the field of electronics is its use to evaporate silver on the surface of quartz plates in such a manner that wires may actually be soldered to the coating. Another adaptation of the unit is in the production of mirrors by evaporating metals such as alum-



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Neutralizing Condenser

FOR 45,000 VOLTS BREAKDOWN?

Here it is! With one inch spacing and rounded edges on all adjacent parts; this new type TN condenser has a capacity range of 33.1 to 12.6 mmf. Rough adjustment of capacity is made by moving the outer cylinder within the clamp. Precision settings covering a total range of 12 mmf are secured by rotation of the tuning control shaft which comes out at an angle of 90° to the lengthwise axis of the condenser. The location of this shaft may be changed radially in steps of 45°. The 12 inch scale shown in the above illustration will indicate the approximate dimensions.

A smaller model is available, having a voltage breakdown rating of 35,000 peak volts and a capacity range of 26.0 to 7.2 mmf. Both models can be supplied with larger capacity ratings if desired. Spun and cast aluminum are used in the construction of both models. Connections are made direct to the aluminum castings and leads may come off at any angle. The Johnson line includes a complete range of sizes of similar condensers down to the model N-125, rated at 9,000 peak volts Breakdown.

Write for further information.

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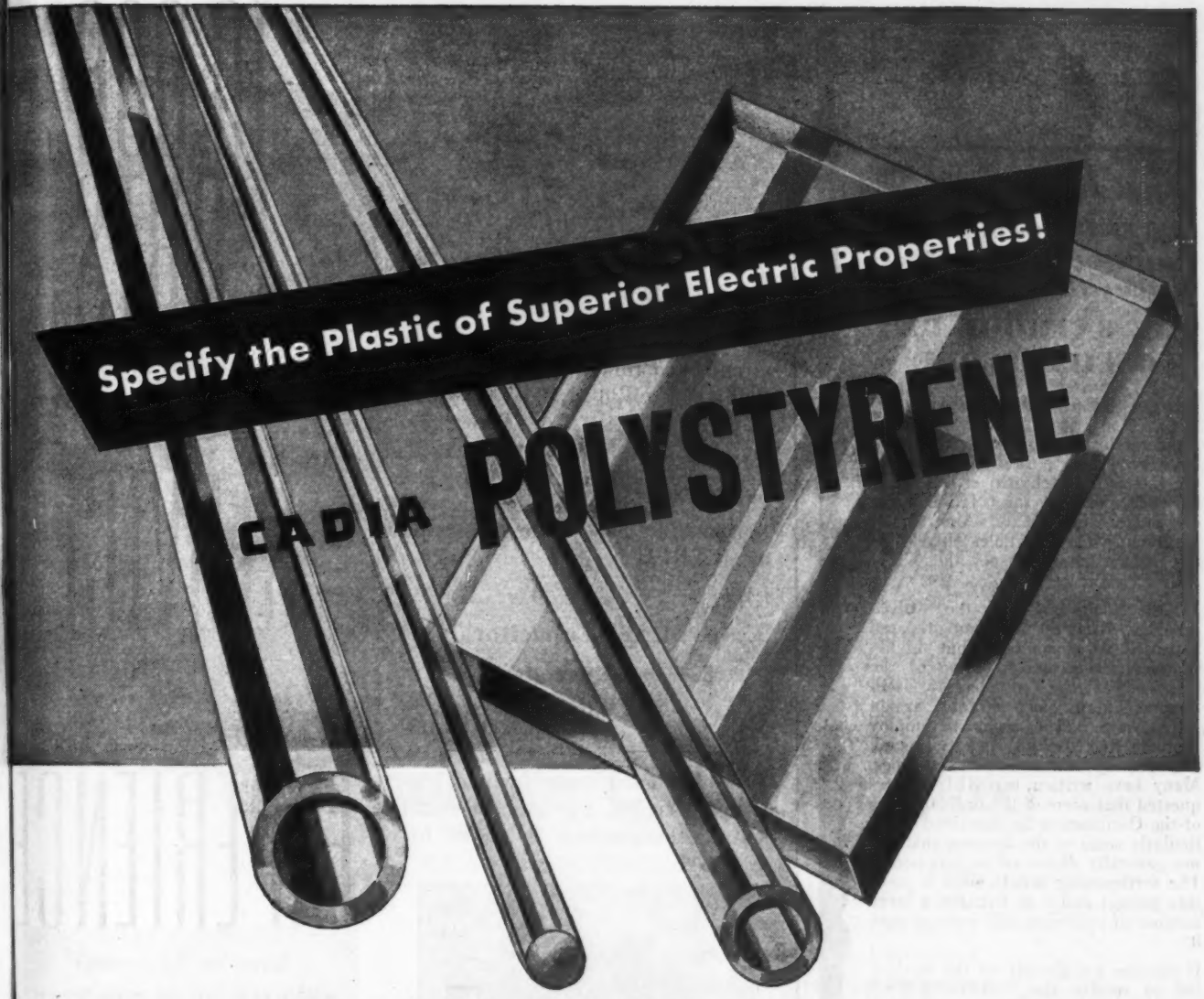

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Consider also these additional values: zero water absorption; relative freedom from adverse effects by acids, alkalies, alcohol, stack gases, weather, etc.; an excellent dielectric constant value, and high tensile strength of 3500 to 5000 lbs. per sq. in. Add to these Acadia's wide experience in the plastics field, and you have the reasons why Acadia Polystyrene merits your investigation.

Complete details are available on request—for quick reference some of Polystyrene's outstanding values are given here:

Dielectric Constant	2.5 to 2.6 at frequencies 10^6
Power Factor, 60 cycles	.0001 to .0003
10^3 cycles	.0001 to .0003
10^6 cycles	.0001 to .0008
Dielectric Strength, Volts/Mil $\frac{1}{8}$" thickness	
Short time	500 to 700
Step by Step	450 to 600
Volume Resistivity, ohms-cms	10^{17} to 10^{19}
Heat Resistance	150°F to 250°F
Softening Point	190°F to 250°F
Specific Gravity	1.05

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TECHNICAL NOTES

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Radiomen!

CREI Offers Another Interesting Technical Discussion on Uses of

THE CATHODE RAY OSCILLOSCOPE

Sent Free On Request

Readers of this column each month have been hearty in their praise of the interesting technical articles written each month by the CREI Director of Engineering Texts, Mr. Albert Preisman. These articles appear in our popular monthly paper, the "CREI NEWS."

In the May issue of the "CREI NEWS," Mr. Preisman has prepared a relatively elementary, but highly practical discussion of some of the many uses of the Cathode Ray Oscilloscope. Many men in the armed forces have had occasion to employ Cathode Ray Oscilloscopes in special, and usually secret, military devices. Many have written to CREI and requested that some of the ordinary uses of the Oscilloscope be described—particularly some of the features that are not generally discussed in text books. The forthcoming article aims to meet this request and it is felt that a large number of radiomen will want to read it.

If you are not already on the mailing list to receive the "CREI NEWS," write at once to the address below and ask for your free copy of the May issue which includes the article on the Oscilloscope. All subsequent issues will be sent to you regularly without charge . . . and, of course, without obligation.

★ ★ ★

The subject of "Cathode Ray Oscilloscopes" is but one of many that are being constantly revised and added to CREI lessons by A. Preisman, Director of Engineering Texts under the personal supervision of CREI President, E. H. Rietzke. CREI home study courses are of college calibre for the professional engineer and technician who recognizes CREI training as a proved program for personal advancement in the field of Radio-Electronics. Complete details of the home study courses sent on request.

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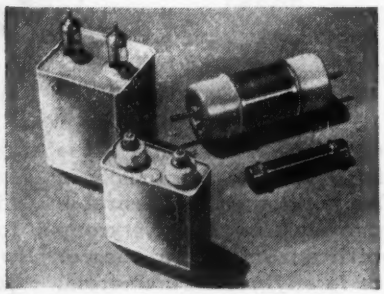
inum, chromium, silver, gold and rhodium on the surface of glass. Many applications of evaporated films on both conductors and dielectrics are being studied by The Vacuum Engineering Division of National Research Corp., Boston 15, Mass.

High-Voltage Capacitors

TYPE 25-P capacitors are for use in high temperatures, and high voltage applications. A special oil-impregnation, called Vitamin Q is used. Standard types include hermetically-sealed, rectangular metal container capacitors in styles for



95 deg C and 106 deg C, continuous operation, and in d-c rated voltages ranging from 1000 to 16,000. Other types include 45-P hermetically sealed in glass shells with metal end caps.

Sprague Electric Co., North Adams, Mass.

Resonance Meter

MW-70 DESIGNATES a resonance meter for use in studying u-h-f phenomena in the laboratory or in the field. It is for use in determining resonance and r-f energy in oscillators and transmitters; tank circuits, antenna systems, coupling networks and transmission lines. The instrument is designed around a high Q concentric resonance cham-

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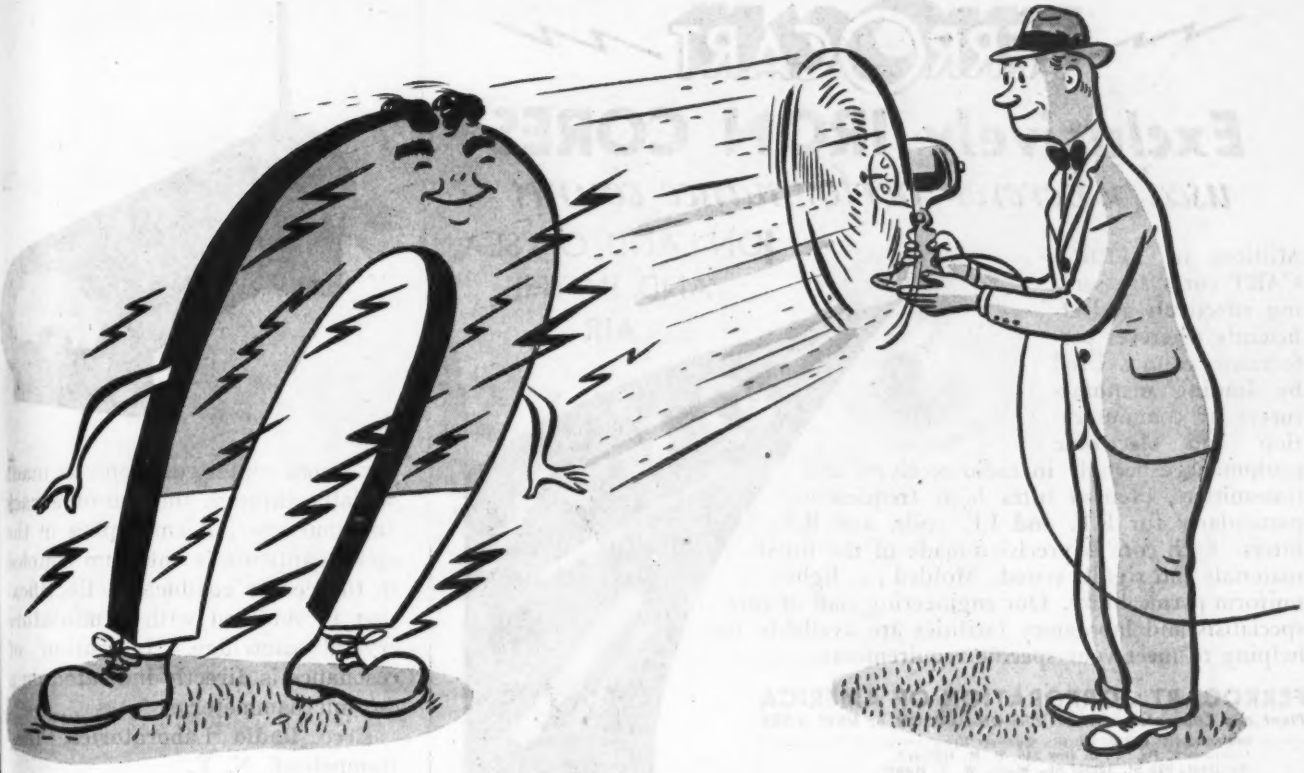

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Yes, magnet metals are mysterious things but our engineers know about all there is known about them to date. We'll be glad to apply our knowledge to the design and manufacture of your magnet.

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ber whose center conductor is made variable through the use of a rack and spur gear. A small plug in the pickup antenna is optimum coupled to the center conductor. Rectification is obtained with a miniature crystal cartridge. Indication of resonance is directly indicated on a d-c microammeter.

Erco Radio Laboratories, Inc., Hempstead, N. Y.

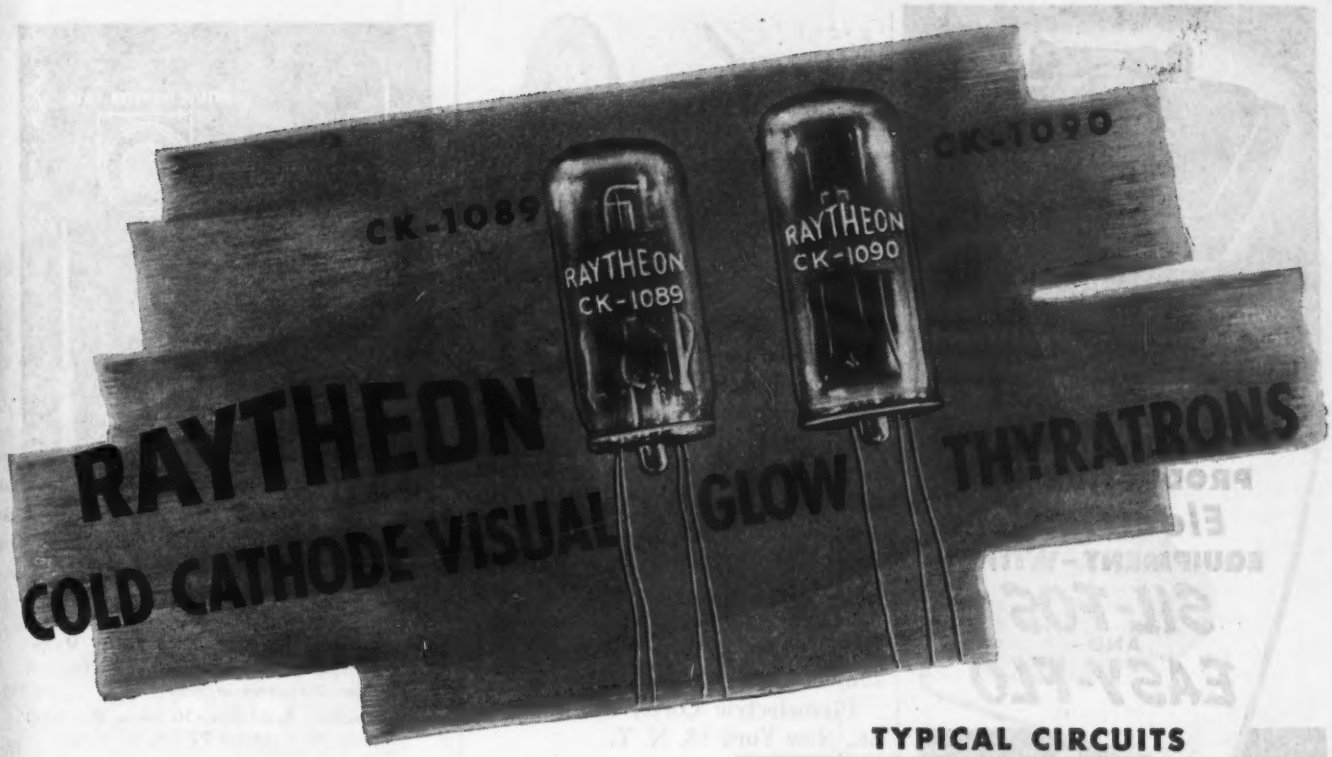
New Chemical Compound

A NEW CHEMICAL compound, Styraloy, is a cross between plastics, rubber and wood. A new million dollar plant is to be built to manufacture the material on a mass production basis. The material is light enough to float on water, it has good electrical properties, can be worked like wood, and molds like plastics. Its electrical properties are low loss, low capacitance and high dielectric strength. It is being used as an insulator in antennas.

Dow Chemical Co., Midland, Mich.

Link Joint

THIS MANUFACTURER uses solid shafting and no flexing or backlash to achieve accurate remote control in a new link joint. The joint features an adjustable link mechanism to transmit rotary motion around corners, and it permits operation of shafts at angles adjustable from a straight line to a right angle of 90 deg. The joint is mounted by means of three screws which hold it in position. The bearing arm holding the adjustable shaft may be hinged to any desired position from zero to 90 degrees and when in its proper location, a locking screw permanently holds its position. The unit



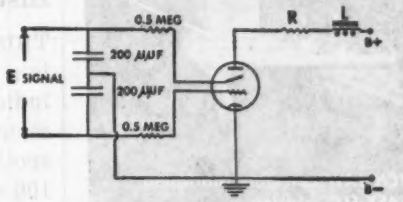
● Outstanding recent developments by Raytheon's research laboratories are two visual-glow cold cathode thyratrons, types CK-1089 and CK-1090.

The former is a tetrode incorporating two starter electrodes and so can be operated from a balanced line, whereas the latter is a triode with a single starter electrode for grounded line or unbalanced operation. In addition to normal grid controlled thyratron performance, these neon-filled tubes are engineered to produce a good visual glow near the top of the bulb.

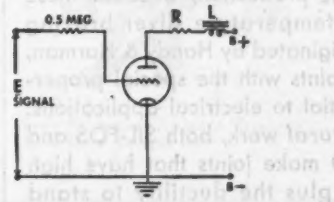
This characteristic, and their small size, make them admirably adaptable to telephone switchboard applications where they can be wired directly as a combined relay and indicator lamp. It is also possible to actuate a separate relay in the anode circuit by the initiation of plate current, which, of course, is coincident with the glow. The resulting simplicity and the reduction in weight and size are highly desirable. Thousands of Raytheon CK-1089 and CK-1090 tubes are now giving dependable service in just such an application—even under the worst climatic conditions. Convincing proof, indeed, that Raytheon builds fine tubes... tubes that you should consider for your postwar products!

TYPICAL CIRCUITS

CK-1089



CK-1090



R = Current limiting resistance. L = Relay coil if used.

SPECIFICATIONS OF CK-1089 AND CK-1090

Minimum Peak Anode Breakdown Voltage (No Signal)	225 volts
Peak Positive Starter-Anode Breakdown Voltage Across Starter Electrodes on CK-1089	75 min. volts 170 max. volts
Starter Electrode to Cathode on CK-1090	
Approximate Starter Electrode Voltage Drop	90 volts
Maximum Peak Cathode Current	20 ma
Maximum Average Cathode Current	15 ma

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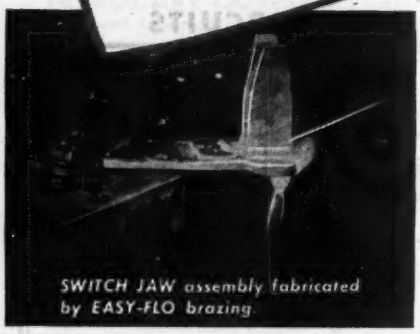
SWITCH BOX COVER made from stampings and parts brazed with EASY-FLO

Better, Faster PRODUCTION OF Electrical EQUIPMENT—WITH SIL-FOS AND EASY-FLO



SWITCH JAW assembly fabricated by EASY-FLO brazing.

BETTER production, because these two low-temperature silver brazing alloys, originated by Handy & Harman, provide joints with the special properties essential to electrical applications. On ***structural*** work, both SIL-FOS and EASY-FLO make joints that have high strength plus the ductility to stand severe stresses and strains. On ***electrical*** work, both alloys make joints that equal the usual current-carrying metals in conductivity and corrosion resistance.

FASTER production, because of the low working temperatures of SIL-FOS (1300°F) and EASY-FLO (1175°F) and their extreme fluidity — factors which also bring down metal joining costs.

GET DETAILS IN BULLETIN 12-A
Investigate the product-improving, production-boosting, cost-cutting possibilities of SIL-FOS and EASY-FLO brazing. ***BULLETIN 12-A*** gives you the complete story. Write for a copy—now.

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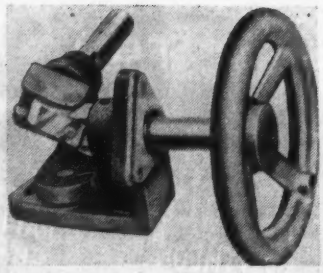
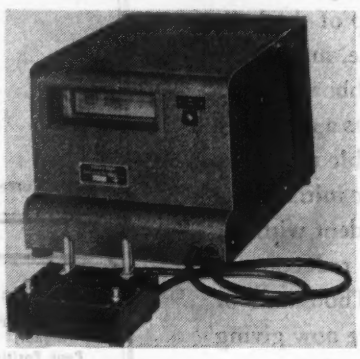


can be used for hand operation and slow speed power drives in the control of electrical switchboards, radios, automatic machinery and other mechanical devices. Another feature is the fact that the output shaft turns in exact angular rotation as the input shaft, giving an input turning angle equivalent to the output turning angle, when used in dial setting operations. Bulletin No. 45 is available on this subject.

Piezoelectric Corp., 110 East 42 St., New York 18, N. Y.

Insulation Resistance Tester

THIS TESTER, Vibrotest Model 238, is a new crankless instrument. The indicating instrument (permanently mounted within the unit) is a spotlight galvanometer having a 100 millimeter scale calibrated from zero to 20,000 megohms, direct reading, at a potential of 500 volts d.c.

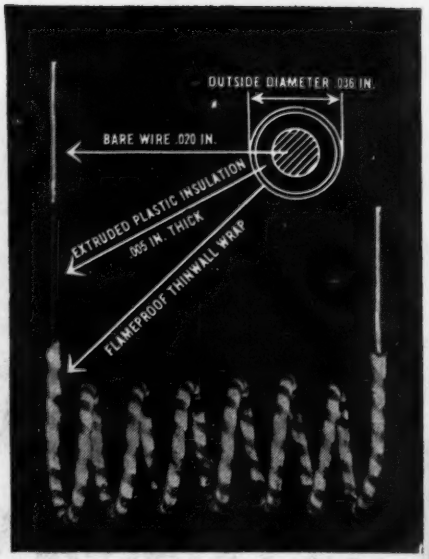


Power is obtained from self-contained batteries. A guard circuit (connected to the unit) is supplied as protection on high ranges. Dimensions are 16 x 11 x 9 in. Weight is 24½ lb.

Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.

Improved Oscillograph

DESIGN CHANGES and refinements have been made in Model 208-B os-



This photo of typical construction is absolutely unretouched

Voltage Breakdown — 7000 Volts
(For spiraled section shown in photograph after 5 minutes in water)
Insulation Resistance—30 Megs. Per 1000 Ft. at 60°F. (After 72 hrs. in water)

SURCO-AMERICAN

New

THINWALL WRAP

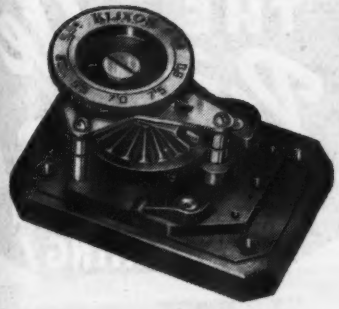
PLASTIC INSULATED FINE WIRE
UNBELIEVABLY THIN

Surco-American Thinwall Wrap is the first uniformly high quality fine wire, with extruded plastic insulation and flame proofed yarn serving, available to industry. Surco-American Thinwall Wrap is characterized by:

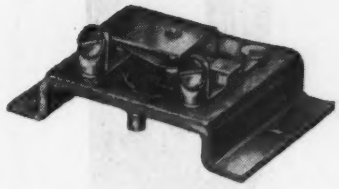
- **High dielectric properties**
- **Maximum saving in space and weight**
- **Unlimited coding and identification**
- **High temperature operation**
- **Excellent abrasion resistance and toughness**
- **Maximum protection against damage by soldering iron**
- **Unusual flexibility at below freezing temperatures**
- **Flameproof qualities**
- **Good end and spot-stripping characteristics**
- **Low cost**

Surco-American Thinwall Wrap is available in a wide variety of formulations finer sizes of wire and thinner insulations than shown above, for use where maximum performance under specific operating conditions is required.

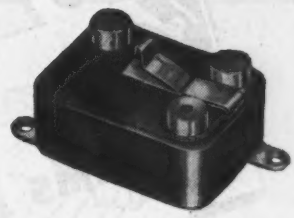
Surprenant
ELECTRICAL INSULATION CO.
Dept. C 84 Purchase St., Boston 10, Mass.



Type RT Thermostat. Adjustable Temperature Control.

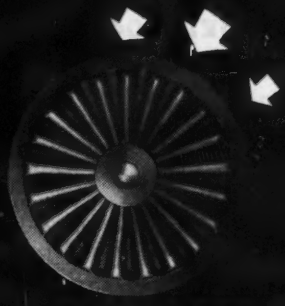


Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

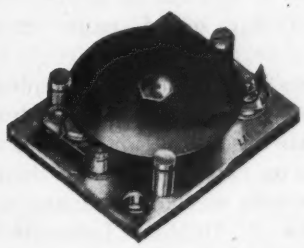


Type C-7220 Precision Snap Switch 12 amps. 30 Volts D. C, 125 Volts A C

This "Business End"

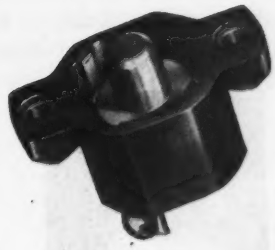


in KLIXON Disc-Operated Controls

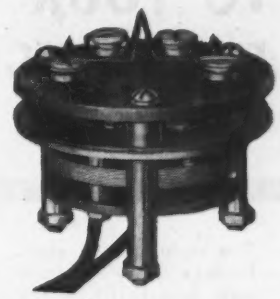


Type B-3120 Thermostat and Heater, Crystal Dew Point Control

Type C-2851 Thermostat For such use as Roughing Controls on Outer Crystal Ovens.



Type PM (NAF-1131) Circuit Breaker



Type ER Series. Ambient Compensated Time Delayed Relays.

ASSURES TROUBLE-FREE CONTROL or PROTECTION

The reason for the reliability of operation of Klixon Controls lies in the simple Spencer thermostatic disc. This foolproof actuating element snaps to a quick, clean "break" or solid "make". Its accurate operation is unaffected by shock, motion, vibration or altitude . . . no matter how often the disc operates.

Klixon Controls are small, compact and light in weight. They are available in many standard types and ratings to meet practically every control or protection requirement such as motor or transformer overheat protection, electrical circuit overload protection, thermal time delays or temperature control for radio equipment. Write for complete information today.

KLIXON

SPENCER THERMOSTAT CO., ATTLEBORO, MASS.

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MAY HAVE
THE "Key"
TO YOUR
ELECTRONICS
NEEDS

The right use of electronics may unlock new possibilities for your postwar product, or open the way to new efficiency on your production line. Bell engineers may have the key — the electronic answer — to your needs! BELL's wide experience in designing and building electronic assemblies and controls — from the earliest developments right through to the latest types — qualifies them to serve you. Your inquiry will not obligate you in any way.

AMONG PRESENT BELL PRODUCTS ARE — Electronic Sound Devices — Intercommunicating Systems—Industrial Voice-Paging and Broadcasting Equipment — Permanent and Portable Amplifying Systems—Recording and Disc Playing Units — Electronic Controls — Operating Sequence Recorders — Other Special Devices.

BELL SOUND SYSTEMS, INC.
1189 Essex Ave. Columbus 3, Ohio
Export Off. 4900 Euclid Ave., Cleveland 3, Ohio

cillograph to make it more rugged and dependable in field service and in rough handling. Some of the changes in the instrument include the use of mineral oil impregnated, hermetically sealed, paper capacitors; high-voltage wire; tube changes; inclusion of a frequency-range adjustment potentiometer in the time base; addition of mounting straps on capacitors; tube clamps; and certain mechanical changes.

Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J.

Capacitors

FIXED ceramic-dielectric capacitors which conform to joint Army-Navy specifications are available in quantities in preferred temperature co-

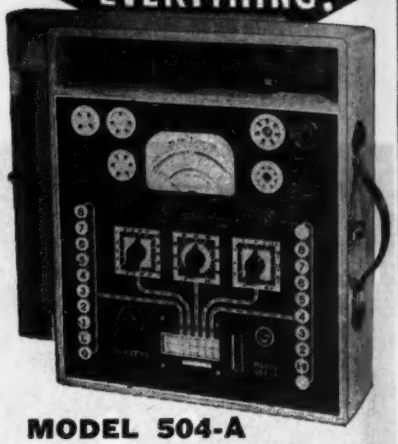
efficients for any capacitance under designations of CC20, CC25, CC30, CC35, CC40 and CC45.

Micamold Radio Corp., 1087 Flushing Ave., Brooklyn 6, N. Y.

Portable Amplifier

FOR A WIDE variety of applications there is a new, portable 30-watt amplifier (designated as W-J) which is being manufactured by Walker-Jimieson (distributors of electronic and radio equipment). The unit is distortionless and humless. It operates on 110-volt, 60-cycles, ac. Output impedances of 4, 6, 8 and 500 ohms may be selected at will. Fre-

THE Portable LAB
THAT GIVES YOU EVERYTHING!



MODEL 504-A
TUBE AND SET TESTER

★ Design proven by over 5 years production of thousands of this model.
★ Operation as simple as ABC. Multi-section push-button switches do all work. Simply "follow the arrows" for tube checking. No roaming test leads for the multimeter.
★ Open face wide scale 4¼-inch rugged meter built especially for this tester—500 microampere sensitivity.
★ Each AC and DC range individually calibrated.
★ Professional appearance. Solid golden oak carrying case.
★ Guaranteed Rectifier.

SPECIFICATIONS

DC MICROAMPERES:
0-500

DC MILLIAMPERES:
0-2.5-10-50-250

DC AMPERES
0-1-10

DC VOLTS—1000 OHMS PER VOLT:
0-5-25-100-250-500-1000-2500

AC VOLTS
0-5-10-50-250-1000

OUTPUT VOLTS:
0-5-10-50-250-1000

OHMMETER:
0-200-2000-20,000 OHMS
0-2-20 MEGOHMS

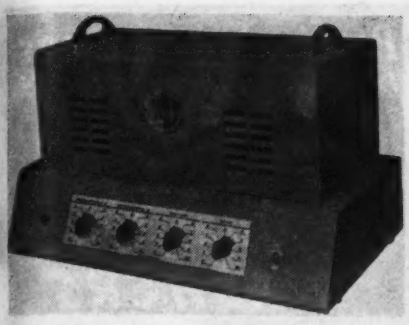
BATTERY TEST:
Check Dry Portable "A" and "B" Batteries Under Load

CONDENSER CHECK:
Electrolytics checked on English Reading Scale at Rated voltages of 25-50-100-200-250-300-450 volts.

TUBE TESTER:
Emission type with noise test, floating filaments, easy chart operation. Checks all receiving type tubes.

POWER SUPPLY:
115 volts 60 cycle. Special voltage and frequency upon request.

SUPREME
SUPREME INSTRUMENTS CORP.
Greenwood, Miss., U. S. A.



quency response is 50-10,000 cycles. Record gain is 69 db, and the mike gain is 116 db. Units come in steel cabinets which measure 17 x 10½ x 19½ in. 311 South Western Ave., Chicago 12, Ill.

Crystal Holders

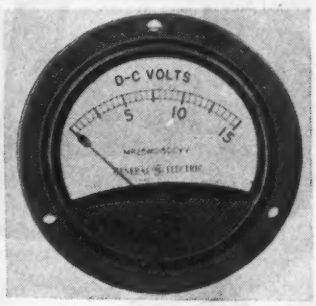
AN IMPORTANT feature of this line, No. FT-243, crystal holders, which have passed all Signal Corps tests, is the fact that they prevent deterioration of the crystal by repelling water vapor when used under tropical conditions.

National Electronic Mfg. Corp., 22-78 Steinway St., Long Island City, N. Y.

G.E. Instruments

FOUR NEW TYPES of instruments are available from General Electric Co., 1 River Road, Schenectady 1, N. Y.

First, there is a new line of 2½-in. hermetically-sealed panel instru-



ments: d-c voltmeters and ammeters and a-c r-f ammeters, which are available in standard ratings and which conform to performance requirements of ASA Specifications C-39.2-1944. Hermetic sealing is achieved by glass-to-metal seals and soldered joints so that the instruments are unaffected by thermal or mechanical shock, or fatigue vibration. Units are housed in steel cases and are immune from effects of

Mark Twain was right then -

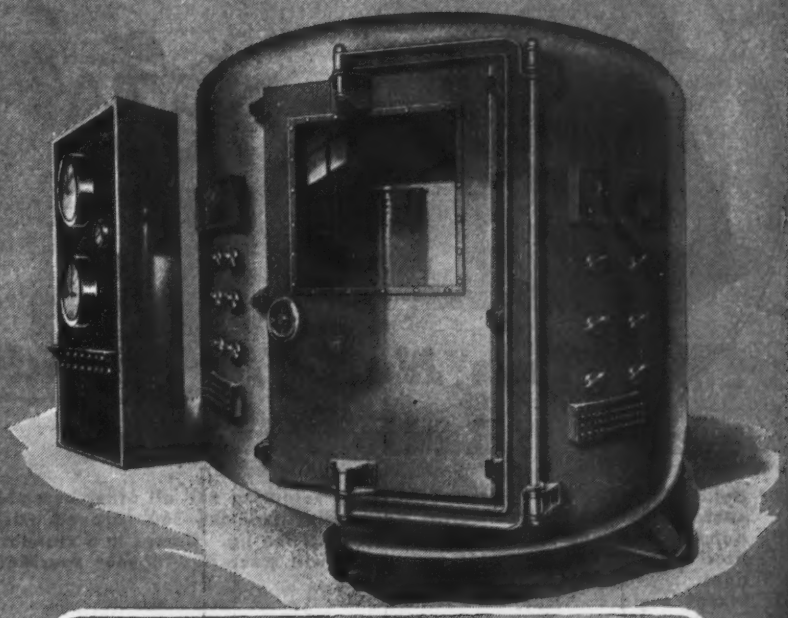
BUT!

When Mark Twain said "lots of folks complain about the weather but no one does anything about it," he was right. That was quite some time ago. But something has been done about it since.

In a Kold-Hold Altitude Chamber, any kind of weather known on the face of the earth can be developed at will for testing and/or calibrating both aircraft and electronic equipment. The temperature range available is from 176 deg. F. to minus 94 deg. F. Pressure range is from sea level atmospheric pressure to 1.25 inches mercury and any degree of humidity from 25% RH to 95% RH.

The weather inside the chamber can be changed from that of a tropical jungle to the intense cold of the stratosphere as rapidly as a plane can climb from sea level to its ceiling.

Write for Bulletin AC-441.



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Baby Incubators—essential to maintaining life in babies born prematurely — are temperature-controlled by accurate, sensitive Fenwal THERMOSWITCHES.

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The QUADRIGA MFG. CO.
Incorporated 1894 "Half a Century"
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This *New Jig Speeds* Radio Assembly

1) Holds chassis in any position to step up soldering and all other assembly operations. 2 models (friction or positive indexing 360° around axis).
2) Adjustable to any size within base limits of the jig. Comes in 5 standard sizes (4", 6", 9", 12" or 15" swing), or will make jigs to your specifications.
3) Sturdy, rigid construction.
4) Can be loaded and unloaded in two seconds.
5) Prices start at $11.50.

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SPECIALISTS IN MASS PRODUCTION TOOLS

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Immediate Delivery!

WIDE RANGE VACUUM TUBE VOLTMETERS

- High input impedance for both AC and DC measurements.
- Convenient, low capacity "Probe," especially adapted to high frequency radio use—100 megacycles and over.
- Self-regulating operation from power line; no batteries.
- Multiple voltage ranges — accurate and stable.

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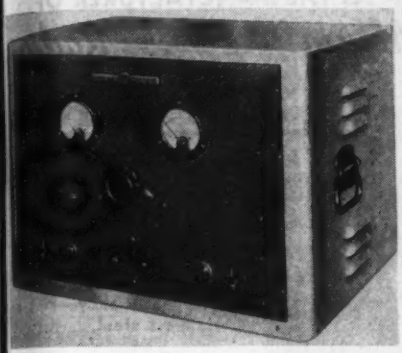
ALFRED W. BARBER LABORATORIES

34-04 Francis Lewis Blvd. Flushing, N. Y.

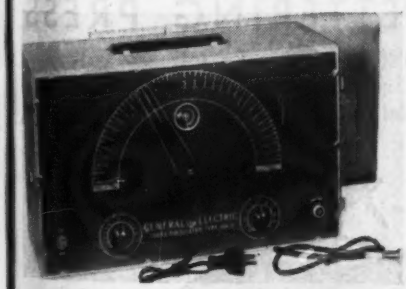
moisture, humidity, chemical fumes, and other harmful agents. They are made for flush mounting on non-magnetic or steel panels.

The second instrument is Type PS-5, a new self-contained regu-



lated power supply which will hold d-c output voltage constant at any selected value, within the range of 160 to 1500 v, regardless of moderately large or rapid changes in the load current. The unit has a low internal a-c impedance useful as a power supply for devices requiring practical elimination of common coupling. Units may be used as component parts or as general purpose gadgets, or as d-c supply for micro-wave oscillators, or for photoelectric multiplier tubes.

A new beat-frequency audio oscillator (Type AO-2) simplifies measurements of audio amplifiers and radio receiver fidelity. The instrument can also be used for test-



ing loudspeakers, for frequency measurements or calibration. Calibration is direct. The unit provides a stable sine wave, continuously variable frequency from 25 to 15,000 cps. A panel control knob regulates the output level from zero to full power output. Zero beat is indicated by the use of Type 6R5 electron-ray tube. Maximum output of the device is 120 milliwatts on the cathode-follower output impedance coupling circuit.

The last instrument is type CRO-3A portable oscilloscope for

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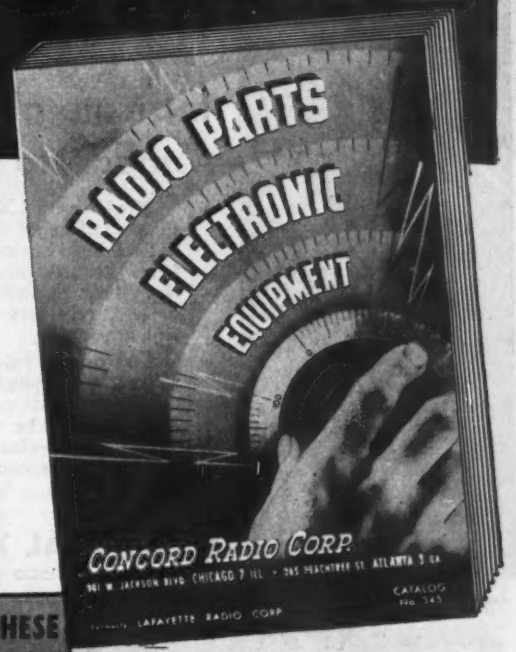

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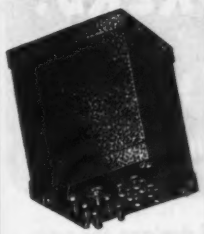
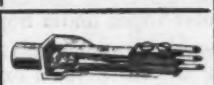


Power Transformer
Pri. 110, 200, 220, 240 Volts 50-60 cycles. Sec. 6.3@1.45 A. 5V@2A. 376 Vct. @ .025 A. 5B5016. . . $3.95

I. F. Transformer
10 Megacycle I. F. Transformer in heavy aluminum can. Size: 3¾" H, 1 15 16" W, 1½" D. 5B5017 $2.95

Telephone Switch
Lever type switch D. P. D. T. No knob supplied. Dull black finish with chrome plated lever. 5B4026. . 59c



Phone Jacks
Switchboard type 2 circuit normally closed. Takes standard tip and sleeve plug. 5B6927 . . . 49c

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The Universal X-Ray plant specializes in the production of metal-to-glass seals. Intricate glass seals are made to customers' specifications for electronic tubes, transformers, resistors, capacitors, condensers, vibrators, switches, relays, instruments, gauges, meters, receivers, transmitters, and other scientific apparatus.

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TO THE MANUFACTURER OF
Miniature Tube Radios

★ STAR
DOUBLE-CHECK SYSTEM

#JE-10—Miniature socket wiring plug for accurate alignment of miniature socket contacts during wiring. Precision cast of zinc base alloy—Pins of stainless steel.

#JE-12 — (Hardened tool steel insert) or JE-13 (Stainless steel insert) Miniature tube pin straightener to obtain a perfect fit when the tube is placed in the set.

For complete information and prices—write

RADIO ACCESSORY DIVISION

STAR EXPANSION PRODUCTS CO.
147 Cedar St., New York 6, N. Y.

CRYSTAL MANUFACTURERS!

Here is a ***NEW*** Holder, approved by the Signal Corps.

Featuring new materials and designs, the new Nemco Crystal Holders have easily *passed every test to which they have been subjected by the Signal Corps. and crystal manufacturers.*

Nemco Holders are designed to prevent deterioration of the crystal by repelling water vapor under tropical conditions.

Because we *specialize in the manufacture of Crystal Holders exclusively,* we can give you the quality and service to help speed your production.

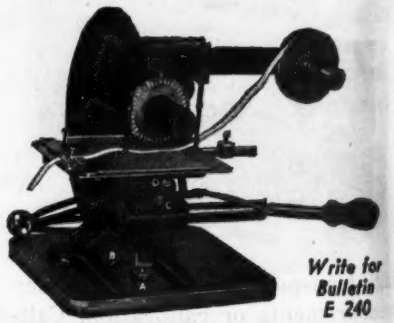
Write for samples and prices; also request quotations on your requirements for imprinting holders with metallic ink.

New NEMCO N5X in No. 6105 and 592 may be obtained in all types of FT-243 Holders.

NATIONAL ELECTRONIC MANUFACTURING CORP.
22-78 STEINWAY ST., LONG ISLAND CITY, N.Y.

NUMBERALL

NUMBERING and LETTERING PRESS



Write for Bulletin E 240

An ideal machine for hot stamping letters and figures on plastic nameplates, and other small parts, with the use of colored roll leaf. Furnished with an electric heating element, and rheostat for regulating heat. All figures and entire alphabet are on one dial.

•

We also make numbering machines . . . automatic and non-automatic . . . for stamping, either hot or cold, numbers and letters into various materials.

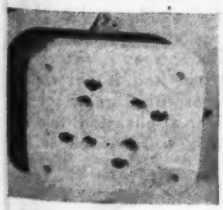
NUMBERALL STAMP & TOOL CO.
HUGUENOT PARK STATEN ISLAND 12, N. Y.

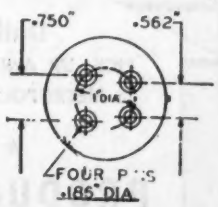
studying wave shapes and transients, measurement of modulation adjustment of radio receivers and transmitters, the determination of peak voltages, and the tracing of electron tube characteristics. The

unit utilizes a 906-P1 cathode-ray tube which has a greenish screen that can be viewed in daylight. Special design eliminates a-c ripple from the a-c transformer field and sharpens the signal picture. Moderately high-speed traces can be photographed on the screen. The unit has a wide range sweep circuit featuring a linear amplifier. Sweep rates are from 10 to 30,000 per second, adjustable by a 7-point vernier switch.

Transmitting Tube Socket

A TRANSMITTING TUBE socket (Catalog No. 244) of low-loss steatite construction is designed to accommodate jumbo 4-prong bases of 8008, BR6, GL146, SC22, GLI52 and GLI69 tubes. The socket measures 2¼ x 2⅝ x ¾ in. thick. A one-piece base construction is used. Bosses are molded in on top of the socket, and are ground to present a flat mounting surface underneath a





chassis. Cadmium-plated brass contacts with steel spring reinforcements are riveted to the ceramic base so that they cannot turn.

E. F. Johnson Co., Waseca, Minn.

QUALITY CONTROL
The Case Tests

Careful control of quality in essential parts is good insurance for smooth flowing production and for a high calibre product.

Thus Deep Drawn, Seamless Steel Cases, an essential part of many Chicago Transformers, are subjected to precision checks for case dimensions, pull tests for strength of spot welds in internal mounting structures, and inspection for electro-plating thickness with carefully timed acid erosion.

By this type of Quality Control, applied in every phase of manufucture, uniformity of parts is maintained and high standards of quality in finished Chicago Transformers is assured.

CHICAGO TRANSFORMER

DIVISION OF ESSEX WIRE CORPORATION

3501 WEST ADDISON STREET

CHICAGO, 18

"MIGIT"
SMALL TOOL SET

A Little Giant For Business!

Saves carrying a lot of tools . . . . .

4 Single Hex, 4 Double Hex, 3 Double Square Sockets. Range 3/16 to 7/16. Universal Drive with Sliding Bar a Spintite Straight Drive all in a pocket size nicely finished metal box. Ask for . .

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Literature

Government Contract Termination Bulletin. Joint Army-Navy Termination Regulations to be used by war contractors in the rapid settlement of war contracts. Other printed material pertaining to contract settlements is also available. The government urges all contractors holding war contracts to have their names placed on the mailing list for the Regulation and all subsequent changes. Write to Joint Army-Navy Distribution Center, Lt. E. P. Lull, 90 Church St., New York, N. Y.

Permanent Magnets. General information regarding the composition, treatment, and properties of magnetic material and the design and testing of permanent magnets are treated in a circular of the National Bureau of Standards (C448). The booklet is entitled, "Permanent Magnets," by Raymond L. Sanford, and is available at 25 cents from U. S. Government Printing Office, Superintendent of Documents, Washington 25, D. C.

Norelco Electronic Products. This 8-page booklet is really a general catalog which uses little space to tell much about such products as cathode-ray, transmitting, power and amplifier tubes; quartz crystal oscillator plates; Searchray (x-ray) inspection units; Geiger-counter x-ray Spectrometer; film-type x-ray diffraction equipment; quartz crystal x-ray analysis unit; metallurgical products and medical x-ray equipment. North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y.

Electronic Tubes. This 20-page, loose-leaf booklet contains diagrams and specifications of such power and transmitting tubes as: Type 3-16 ballast; Types 3B27, 371-B, 836 and 8020 half-wave high-vacuum rectifiers; Types 866-A/866, 575-A, 872-A and 8008 half-wave mercury-vapor rectifiers; Types 100-TH (tantalum anode), 811 and 812 (Zirconium-coated anode), and 808 transmitting triodes; Types EE-200 and EE-300 power amplifier, oscillator, class B modulators; Types 873 and

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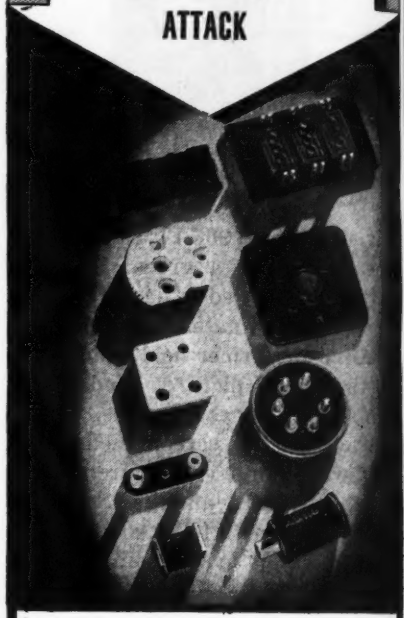

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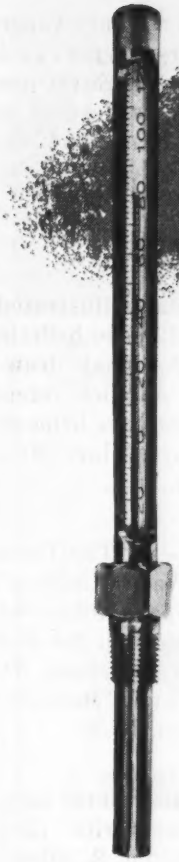

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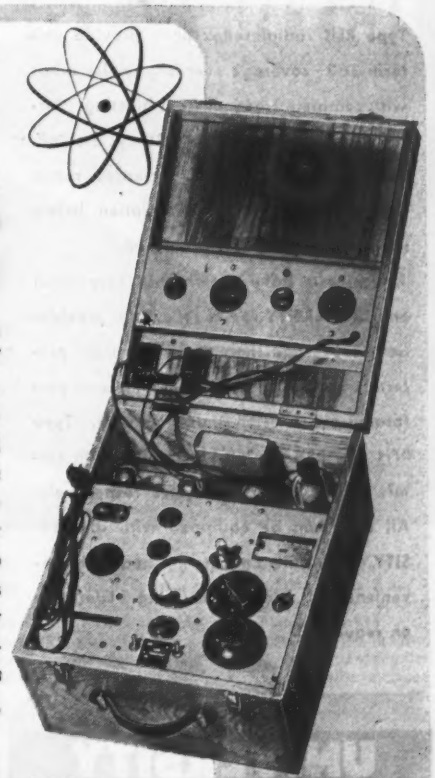

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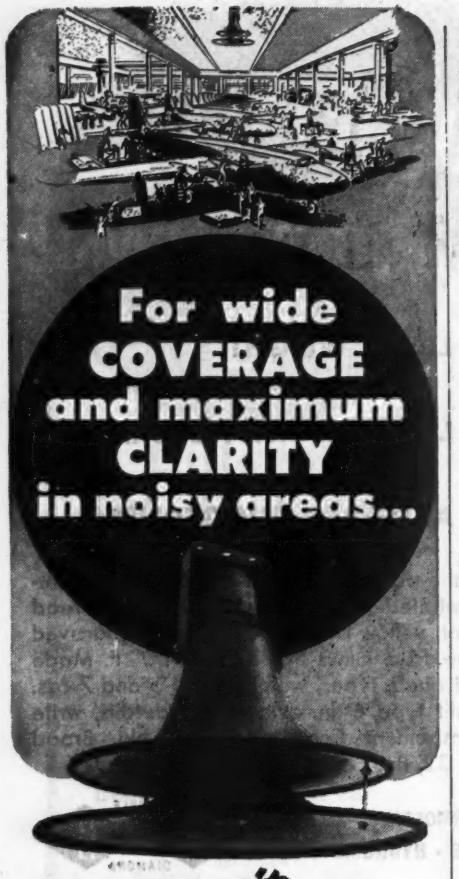

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EE-17 half-wave mercury-vapor, grid control rectifiers; Types 274-A and 274-B, full wave high-vacuum rectifiers. One page is devoted to the operation of E-E mercury vapor rectifier tubes. Electronic Enterprises, Inc., 65-67 Seventh Ave., Newark, N. J.

Relays. Aircraft relays illustrated and described in a 12-page bulletin (No. 30-D). Dimensional drawings are included. A quick reference index on the last page helps to locate specified relays. Hart Mfg. Co., Hartford, Conn.

Square Wave Analysis. "The Technique of Square Wave Analysis" is the title of a 4-page folder on this subject. Described on the last page of the folder is Model 71 square wave generator. Measurements Corp., Boonton, N. J.

Transformers, Chokes, Motor Generator. Wyse Laboratories (211 S. Ludlow St., Dayton 2, Ohio) 4-page folder announces the establishment of a department for the production of special transformers and chokes. Several pieces of equipment are illustrated. Another 4-page folder from Wyse is devoted to a brief description of a new, portable MG-39 motor generator built for U.S. Signal Corps for testing 400-cycle a-c and 27-v d-c instruments.

Permeability Tuning, Iron Powders. "Incremental Permeability Tuning" is the title of an article (reprinted from *Radio*) by W. J. Polydoroff describing a tuning system utilizing incremental permeability. Applications are indicated. Another piece of literature contains curves establishing the relation between the effective permeability of powdered compressed cylindrical cores and the permeability of the material itself, as measured in toroidal coils at low flux density. Five other pieces of literature include an 18-page catalog entitled "Carbonyl Iron Powders;" a sheet entitled "Electromagnetic Characteristics of Various Iron Powders;" 2-pages of data giving the comparison of different grades of carbonyl iron powders manufactured; and finally a 6-page

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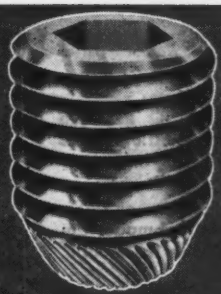

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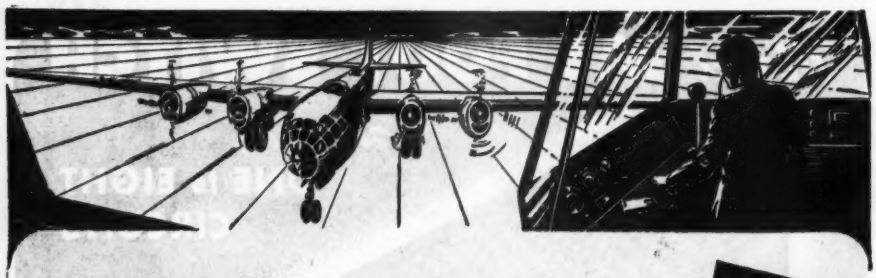

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folder on "Polectron" products which are synthetic organic resins for coating and impregnating uses in the electrical field. General Aniline & Film Corp., Special Products Sales Dept., 435 Hudson St., New York 14, N. Y.

Steatite Insulators, Bushings. "Design Criteria for Steatite Insulators" is the title of a concisely written, illustrated booklet which is designed to give manufacturers and designers an opportunity to become familiar with the mechanical characteristics of Steatite (a ceramic body composed mainly of talc) for use as an insulator on h-f equipment.

Another piece of literature called "Sealex Bushings" describes hermetically-sealed bushings which withstand severe operating conditions encountered in military communication equipment.

General Ceramics and Steatite Corp., Keasbey, N. J.

Variable Capacitors. A 32-page book which contains unusually good illustrations and brief descriptions of approximately eighteen types of capacitors, as well as the facilities of this manufacturer to produce these components. The Hammarlund Mfg. Co., Inc., 460 West 34th St., New York 1, N. Y.

Insulating Varnishes. Insulating varnishes and compounds are described in a 56-page informative booklet which contains many helpful charts, tables and articles compiled for the purpose of providing a direct approach to insulating varnish problems. Four pages of the booklet are devoted to a short history of insulating varnish. The booklet is well illustrated. John C. Dolph Co., 168 Emmett St., Newark, N. J.

Electronic Heating Equipment. A loose-leaf catalog entitled "Industrial High Frequency Heating Equipment" contains a series of bulletins on the subject. Bulletin No. 401 is an introduction to inductive heating; bulletin No. 412 tells about induction furnaces; bulletin No. 413 describes, with the aid of charts and pictures, furnaces and crucibles; bulletin No. 414 tells about Trunnion-type furnaces;

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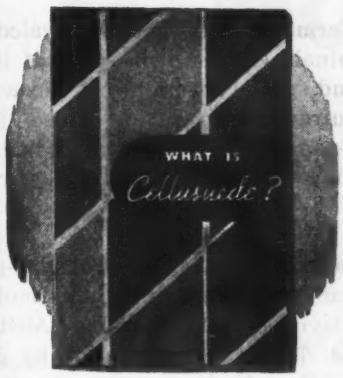

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bulletin No. 415 is devoted to foot-lifting furnaces. Ecco High Frequency Corp., 7020 Hudson Blvd., North Bergen, N. J.

Terminals. Hermetically-sealed terminals (including a stock of items and special forms to meet exact requirements) are described in a 1-page form. Electrical Industries, Inc., 42 Summer Ave., Newark 4, N. J.

Jobs in Television. A new 6-page leaflet on postwar occupations in television (Occupational Abstract No. 74) is a contribution by John E. Crawford of RCA. In brief, readable style the author discusses postwar prospects, training required, methods of entrance and advancement, range of salaries, advantages and disadvantages of television as a career. Sources of further information on the subject are given. Available for 25 cents from Occupational Index, Inc., New York University, Washington Square, New York 3, N. Y.

Soldering Flux. The advantages of Kwikflux, a hard soldering flux, are given in a 1-page form. Special Chemicals Co., 30 Irving Place, New York 3, N. Y.

Technical Apparatus Literature. Several pieces of literature describing instruments available from Technical Apparatus Co., 1171 Tremont St.; Boston 20, Mass.; include the following:

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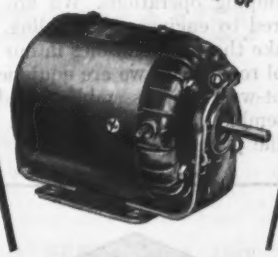

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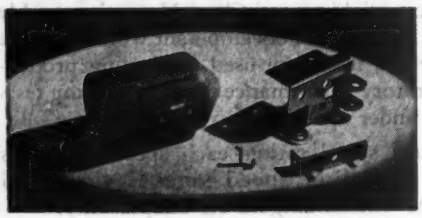

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Reference Manual Holders. Replacement specification sheets and new specification sheets on cathode-ray tubes are now available for owners of a reference manual got out by Allen B. DuMont Labs., Inc., Passaic, N. J.

Junior Engineers' Reading List. A revised "Reading List of Junior Engineers" has been issued by the Junior Committee on Professional Training of the Engineers' Council for Professional Development, 29 West 39th St., New York 18, N. Y. Price, 10 cents each, or 5 cents each in lots of 50 or more.

Capacitor Catalog. Catalog No. 20 contains 56 pages of data and illustrations of paper dielectric capacitors available from Sprague Electric Co., North Adams, Mass. The catalog is designed as a guide to the selection of these components for industrial uses.

Engineering Bulletin. "Multi-Meter Circuits For Use With HC Meter Scales" is the title of a new engineering bulletin (No. 1) which sells for 25 cents. The bulletin as well as HC meter scales are available from R. E. Nebel Laboratory, 1104 Lincoln Place, Brooklyn, N. Y.

Decade Inductance. Five types (2321 to 2325) of decade inductance units are briefly described in a 1-page bulletin. New York Transformer Co., 26 Waverly Place, New York, N. Y.

Automatic Voltage Regulator. Bulletin No. 163 contains specifications, applications, and some illustrations of an automatic voltage regulator for line-voltage control. Superior Electric Co., Bristol, Conn.

H-F Cable and Connectors. For this manufacturer's catalog there is available a new "Section D" which describes 26 types of RG cables and many companion h-f connectors for uhf and electronic applications. A chart giving molded "AN" insert connections is also available. American Phenolic Corp., 1830 South 54th St., Chicago 50, Ill.

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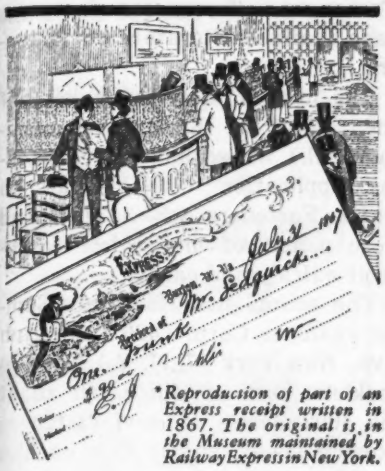

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Ceramics Insulator Bodies. Bulletin No. 444 describes, with the aid of good illustrations, AlSiMag ceramic insulator bodies for electrical and other technical uses. American Lava Corp., Chattanooga, Tenn.

Mica Trimmers. Automatic Mfg. Corp., (formerly known as Automatic Winding Co., Inc.) manufacturers of complete electronic assemblies and component parts, have available a 12-page booklet which illustrates and describes approximately fourteen types of automatic mica trimmer capacitors. 900 Passaic Ave., East Newark, N. J.

Double Coil Washers. Double-coil, spring-lock washers available in any desired finish for No. 4 screws up to 1 in. and larger bolts are described in a leaflet available from George K. Garrett Co., Inc., 1421 Chestnut St., Philadelphia 2, Pa.

Fastener Assembly. A new one-piece fastener assembly (called the Spring Lock Fastener) which does not require nuts or receptacles is described and illustrated in a 4-page folder available from Simmons Fastener Div., Simmons Machine Tool Corp., Albany, N. Y.

Tubes, Television Brochure. "Time, Tubes and Television" is the title of a brochure intended as an introduction to the genealogy of science. It contains many illustrations and covers a lot of territory especially

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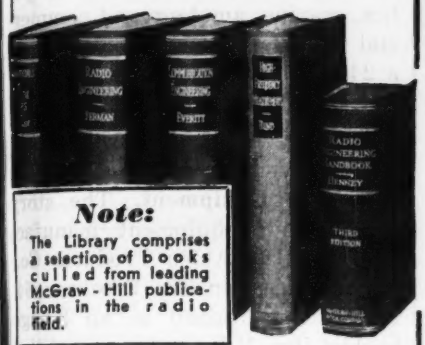

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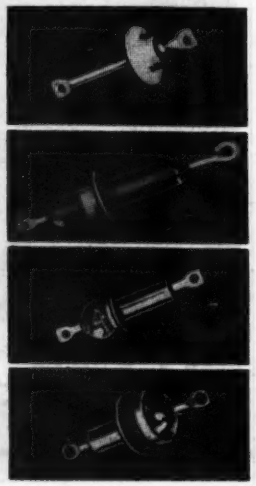

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with regards to the manufacturer's facilities and products. Several pages are devoted to clear illustrations of the cathode-ray gun. Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J.

Tubular Metal Antennas. Construction diagrams, illustrations and descriptive data on antennas and antenna parts for use in police, marine, amateur and commercial installations are contained in a 24-page book. Premax Products, Div. of Chrisholm-Ryder Co., Inc., Niagara Falls, N. Y.

Facsimile Equipment. The story of facsimile equipment manufactured by the Alden Products Co., 117 North Main St., Brockton 64, Mass., is contained in an 8-page booklet by Milton Alden entitled "Suiting Facsimile Designs to Service Needs" reprinted from *FM & Television.*

Cathode-Ray Tubes. A 16-page illustrated booklet on "How & Why Cathode Ray Tubes Work" reprinted from *Communications* from a series of articles by J. R. Beers, Development Engineer, North American Philips Co., Inc. (100 East 42 St., New York 17, N. Y.) Contents deal with early history, manufacturing problems, testing, and special designs. Write North American Philips.

Rotary Electrical Equipment. A 4-page folder contains a brief review and illustration of dynamotors, motors, converters and generators of various types. Eicor, Inc., 1501 W. Congress St., Chicago 7, Ill.

High-Voltage Test Equipment. Bulletin F describes portable kilovoltmeters and multipliers suitable for use from 1 to 30 kv, as well as corona-protected kilovoltmeters and resistors for measurements up to 200 kv. Shallcross Mfg. Co., Collingdale, Pa.

Vertical Radiators. A 4-page brochure illustrates vertical radiators for broadcast stations and antenna supporting poles for other types of service. Handy information is given broadcasters for ground sys-

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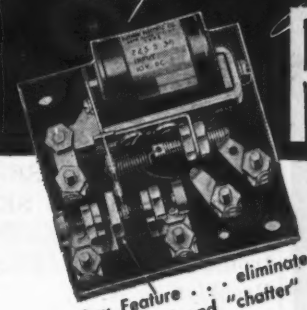

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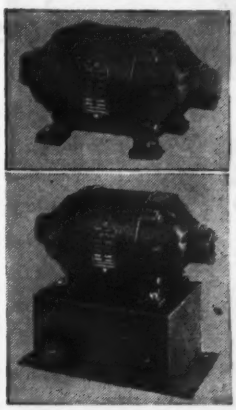

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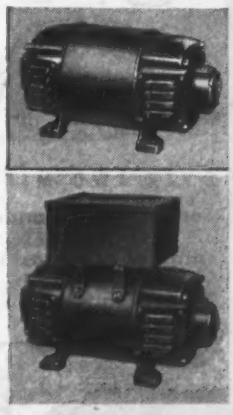

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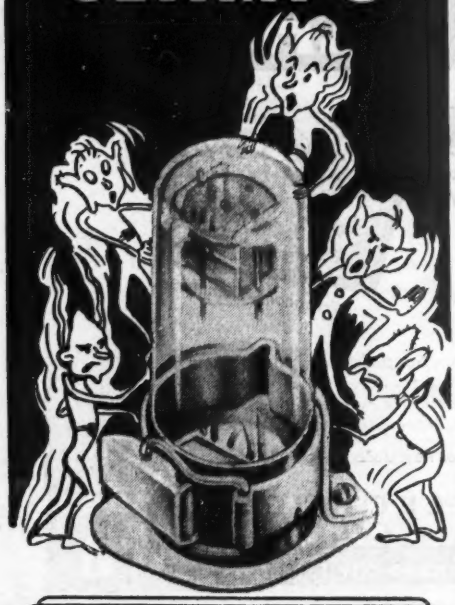

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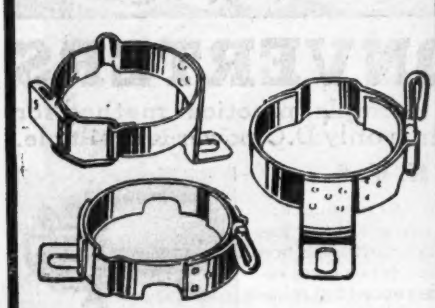

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Television Studio and Transmitting Equipment. A 6-page folder illustrating and briefly describing products such as Model SE-100 television transmitter (video and audio models), SE-300 console studio control desk, SE-200 master control board and SE-400 transmitter control desk. Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y.

Power Connections. Catalog No. 27 contains a good deal of data on power connections for electronic equipment. Harvey Hubbell, Inc., Bridgeport 2, Conn.

Parts and Assemblies. A booklet entitled "Silent Partner For Your Success" gives background data of this manufacturer, and illustrates and describes parts and assemblies. Orange Screen Co., Maplewood, N. J.

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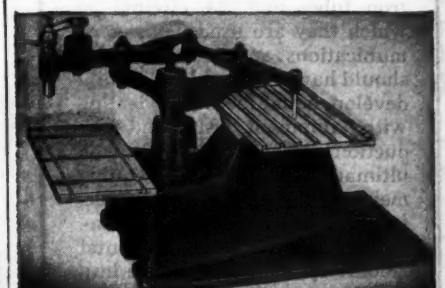

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Prodigal Genius; The Life of Nikola Tesla

By JOHN J. O'NEILL. *Published by Ives Washburn, Inc., 29 West 59th St., New York 19, N. Y., 1944, 326 pages, $3.75.*

THERE CAN BE NO disputing the fact that Nikola Tesla was a great discoverer and inventor, particularly in the field of electrical engineering. At a time when electricity was just beginning to be investigated as a useful tool of mankind he was looking ahead to the days when this force could be controlled for the benefit of everybody. Thus, Tesla was thinking in terms of a-c power when direct current was the only type of electric current available. He was experimenting with world-wide radio when the wireless transmission of code signals was limited to a relatively few miles. And he was developing the wireless transmission of power nearly 50 years ago.

Like most so-called geniuses, Tesla had his shortcomings. For one thing, he was not as much interested in exploiting his discoveries and inventions as he was in making more discoveries. Therefore, he never realized anything from much of his work and opened the door to piracy, intentional or otherwise. Because of his lack of business sense he missed many opportunities to make money with which to continue his work as he would have liked to do. Tesla's personality was attractive socially but lacking in business acumen, so that many financiers who might have backed him did not do so because he was not enough of a "salesman."

But most important of all, Tesla did not commit to writing many of his thoughts and dreams for investigations that he planned to carry out "some day." When he died in 1943 many of his plans, which could have been carried on by others, died with him. It should be noted, however, that all of his papers, dealing with the experiments he performed, have been impounded until after the war. There is no way of telling, at this time, how much those notes have helped the United Nations, if at all.

Mr. O'Neill was a friend and ad-

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Electrical contacts are made in many forms, depending on the function of the contacts, the general type and design of the apparatus, and the relative cost of various contact forms.

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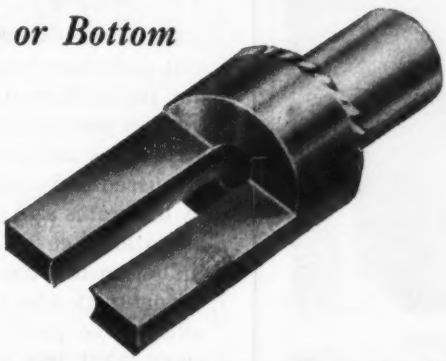

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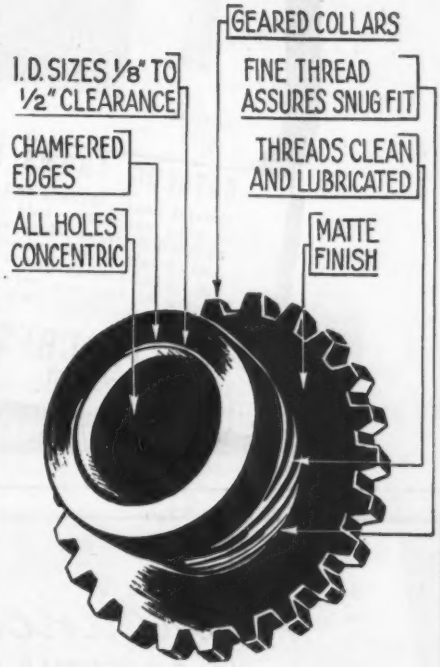

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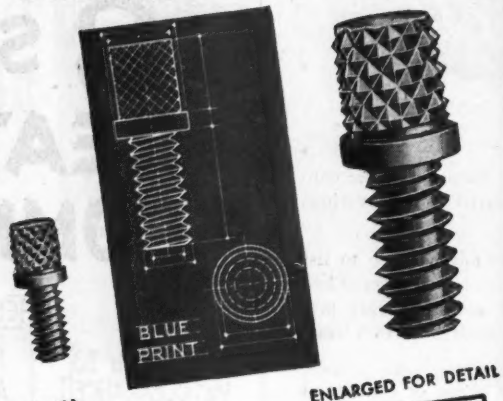

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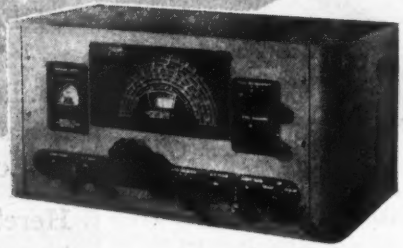

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mirer of Tesla for many years. In fact, his admiration borders on hero worship. It is logical, therefore, that he should write Tesla's biography. Because of his experience as science editor of the New York Herald-Tribune he is able to describe Tesla's work, much of which was highly technical, in simple terms that anyone can understand. This does not detract from the book, however, so far as engineers are concerned because he has faithfully kept to engineering terms wherever possible.

The excessive enthusiasm that the author displays for his subject is boring in spots, particularly when he repeats as frequently as he does his defenses and explanations of Tesla's shortcomings. On the whole, however, the book is well written and documented. A partial list of Tesla's patents and an index are provided. It makes good reading for any engineer or student, particularly those interested in electronics, because it is the life story of a man whose influence on our daily lives will be evidenced for centuries to come.—K.S.P.

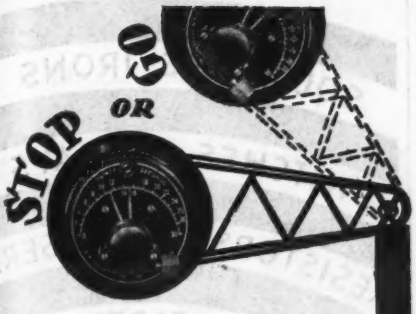
• • •

High-Frequency Induction Heating

By FRANK W. CURTIS, *Consulting Engineer, Springfield, Massachusetts, McGraw-Hill Book Co., Inc., New York, 235 pages, price $2.75.*

EXPERIENCES GAINED from commercial induction-heating installations are the background from which the greater part of this book is written. Principles and practices, which are discussed and amply illustrated both by diagrams and photographs of installations, cover a wide variety of induction heating applications. The opportunity that this presentation affords the production engineer to learn what has been proven effective in industrial heating applications, plus the fact that this is the first book to be devoted entirely to high-frequency heating, make it a useful guide both to designers of electronic heating equipment and to those who are or plan to use such apparatus.

The first sixth of the book, devoted to the principles of induction heating, unfortunately includes a number of statements open to question. For example, it is explained that "Since induction heating is



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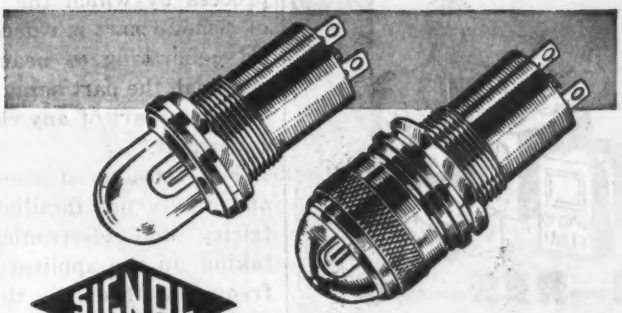

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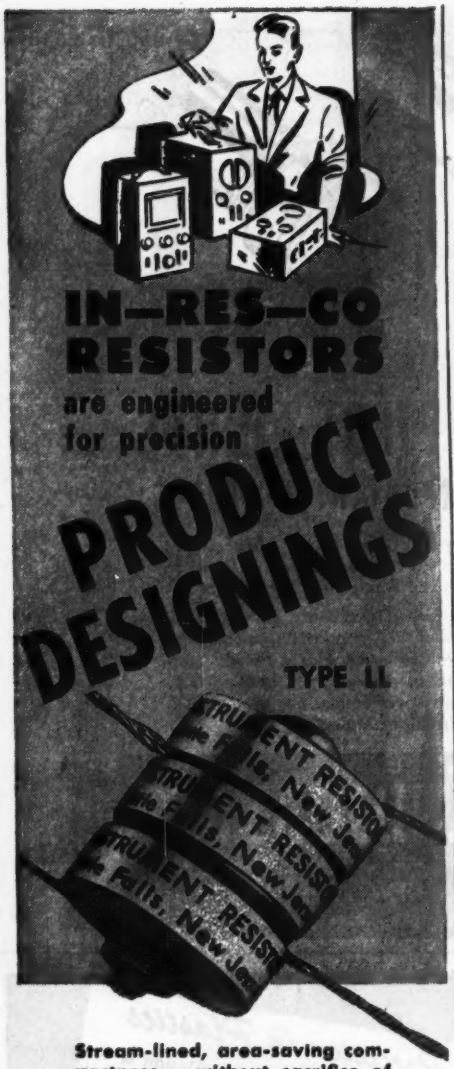

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process by which the temperature of a metal part is raised by electrical generation of heat within the material, the part being heated is in no way a part of any closed electrical circuit."

For those production engineers and others not familiar with electricity and electronics who are taking up the application of high-frequency fields to their heating problems, considerable more information on principles of electronic heating will be required than is given in the short first chapter of this book.

Techniques

The greater part of the book discusses the effect of the applicator coil shape on the area to which heat is applied. Diagrams illustrate the degree and penetration of heat produced by numerous coil contours and show how the coil can be designed to do the job at hand.

Methods of brazing various shapes are described and considerable attention is given to the technique of brazing carbide tools. Soldering techniques are also illustrated. Hardening is covered with special attention to zonal hardening, and setups for hardening complex shapes such as gears are discussed. Semi-automatic equipment is described.

Applications

In a chapter devoted to fixtures for use in hardening setups, methods of handling the work and types and requirements of continuous and automatic fixtures are described. The following chapter describes several miscellaneous industrial-heating applications which illustrate how widely induction heating can be applied if used with ingenuity. For example, one special device uses a phototube to determine when the work has reached the proper temperature by monitoring its color. Power to the high-frequency generator is turned off at the proper time by the phototube unit.

The book concludes with a chapter on special considerations necessary in the design of parts to be heat-treated by high-frequency induction, and a chapter that points out the saving in time, type of applications most suitable for, and the packaged equipment available for dielectric heating.—F.R.

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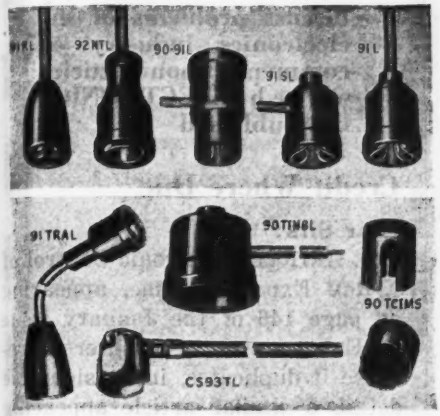

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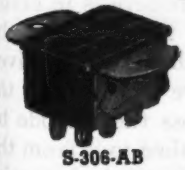

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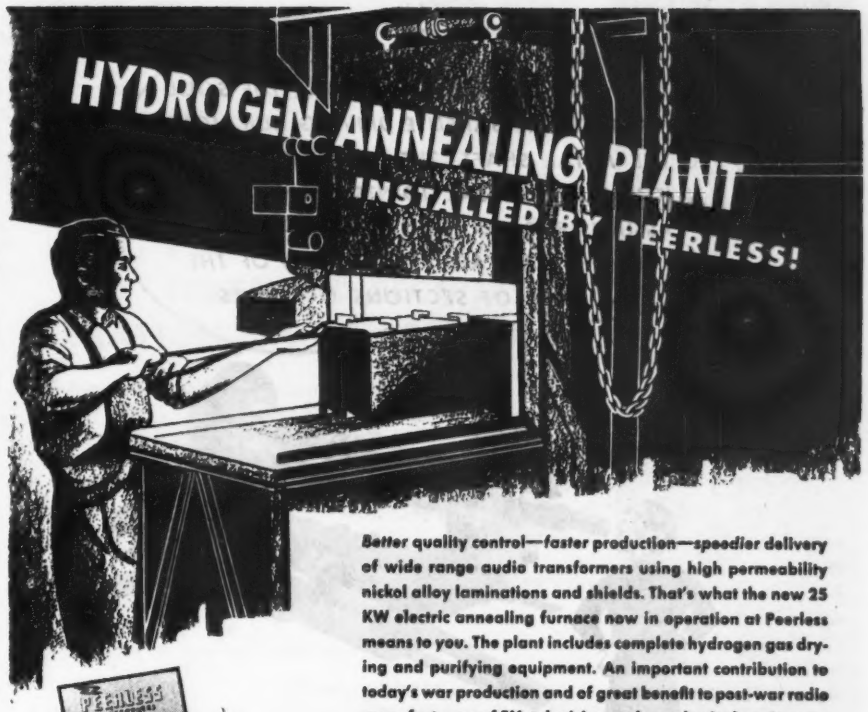

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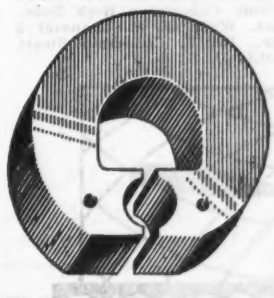

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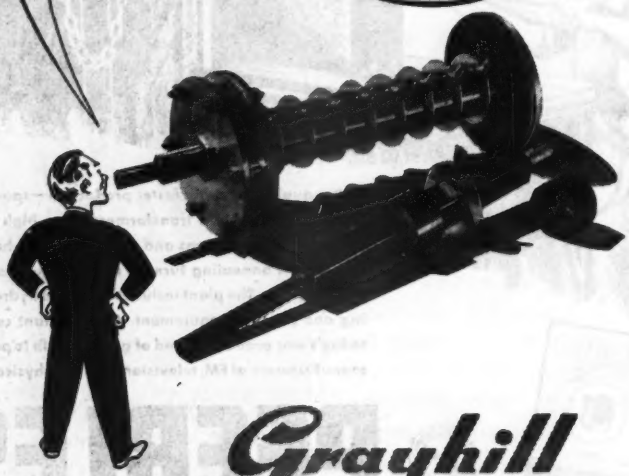

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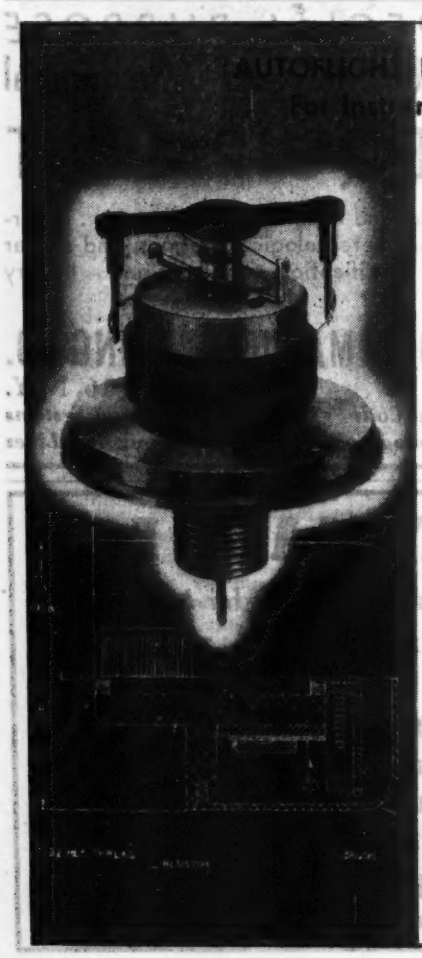

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published

Credit Where Due

Dear Sirs:

THE ARTICLE, Electronic Control of X-Ray Exposure Time, appearing on page 146 of the January issue of ELECTRONICS is of interest because it duplicates, in considerable detail, a similar article appearing in ELECTRONICS for July 1943. . . . I feel that I should recall to your attention that the work described was done at the University of Chicago. As a matter of fact, the Westinghouse model shown on page 146 was copied almost directly from a model supplied to them by the University of Chicago. The University did this in an effort to stimulate commercial production of the device at a time when it was needed in the war effort.

RUSSELL H. MORGAN
Radiology Section
Tuberculosis Control Division
U. S. Public Health Service
Washington, D. C.

• • •

Cathode-Follower Corrections

Dear sir:

THE ARTICLE by Mr. Pacini on Cathode Follower Calculations, appearing on page 137 of ELECTRONICS, October, gives a value for the output impedance of a cathode follower which I believe is in error.

In determining the impedance by assuming the cathode to be driven by a generator we must divide the voltage drop across the cathode by the current furnished to it from the external generator. This is equivalent to Mr. Pacini's analysis only if the R_1 of his Eq. (3) is equal to zero. The equations with their solution are then as follows:

$$R_2 I_1 - R_2 I_2 = E_1 - R_2 I_1 + (R_2 + R_p) I_2$$

$$= -\mu (I_2 - I_1) R_2 \frac{I_1}{E_1} = \frac{\mu + 1}{R_p} + \frac{1}{R^2}$$

$$= g_m + \frac{1}{R_p} + \frac{1}{R_2}$$

The quantity I_1/E_1 is the value of the conductance offered by the cathode to the external generator of

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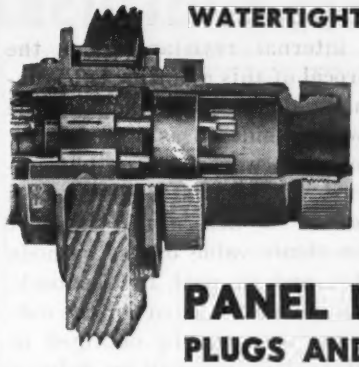

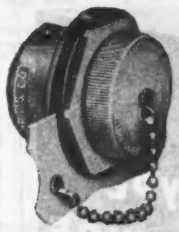

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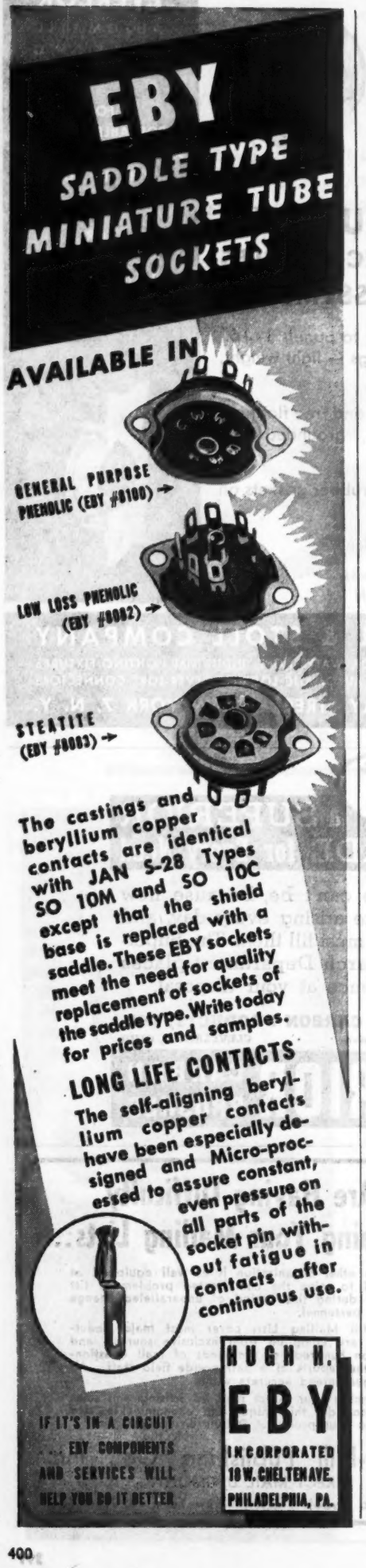
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zero internal resistance and the reciprocal of this quantity is the internal resistance of the cathode follower considered as a generator, or, in other words, its output impedance. It is immaterial that this impedance is determined in part by the ohmic value of the cathode resistor and in part by feedback.

This same expression for the output impedance can be obtained in an alternative manner by solving for the value of load resistor which, shunted across the cathode resistor, will reduce the gain to one half of the unloaded value. Let the gain of the unloaded cathode follower be

$$A = \frac{\mu}{R_p/R_k + \mu + 1}$$

in which R_p is plate resistance and R_k is cathode resistance.

When the load R_L is shunted across R_k the effective cathode resistor becomes

$$R_k' = \frac{R_k R_L}{R_k + R_L}$$

The gain A' with the new value of cathode resistor R_k' will be

$$A' = \frac{\mu}{R_p/R_k' + \mu + 1}$$

$$= \frac{\mu}{2(R_p/R_k + \mu + 1)} \frac{1}{R_k'}$$

$$= \frac{2}{R_k} + \frac{\mu}{R_p} + \frac{1}{R_p}\frac{1}{R_L} = \frac{1}{R_k'} - \frac{1}{R_k}$$

$$= \frac{1}{R_k} + g_m + \frac{1}{R_p}$$

Since the internal resistance of a generator is by definition equal to the load resistance that would reduce the output voltage to one half, it is seen that the output impedance is

$$Z_o = \frac{1}{g_m + 1/R_p + 1/R_k}$$

It is important to note when applying these equations that the values of g_m and R_p will in general be different from the handbook figures since they both depend on the static plate current and this is often less than the value assumed by the manufacturer.

RUSSELL N. SKEETERS
California Institute of Technology, Pasadena, Calif.

Dear Mr. Skeeters:

THE DIFFERENCE in the value of the output impedance of the cathode follower according to your derivations and mine are negligible, in the order of 5 percent or less, if the assumption is made (as I did, between equations 7 & 8) that the amplification factor of the tube is

(*Continued on page* 406)

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much greater than one. In all of my engineering design in the past I have never attempted to use a tube with a μ of less than 20 as a cathode follower, because it would lead to too high an output impedance. I am sure that you will agree with me that the cathode follower is used primarily as a low impedance source.

Equation 5 gives the value of the driving point impedance that the generator emf sees looking into the network. Equation 6 is the output impedance, obtained by subtracting R_1 from Z_1; and you may well see that it is the same as your end result except for the difference mentioned above. The generator could have been assumed to have zero internal impedance, but I chose to make the derivation more general by stating that the network be driven by a generator with internal impedance.

It is useless to calculate vacuum tube behavior to better than 5 percent because of the tolerances allowed by the manufacturers on the characteristics; and the characteristics do vary considerably, as you mentioned, because of the operating point.

Thank you for your interest in the article. I trust that I have clarified the point in question.

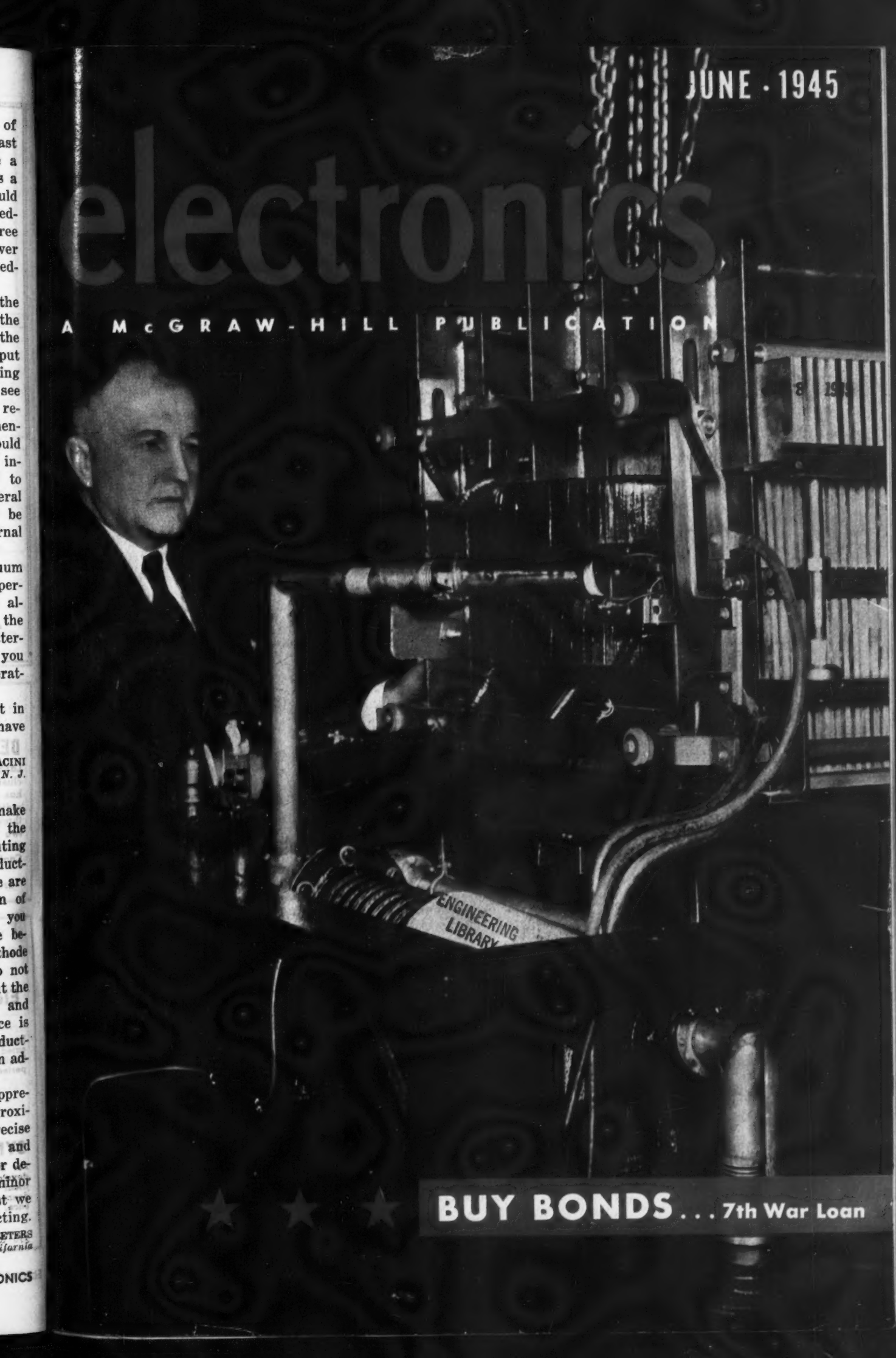
HUMBERT P. PACINI
Asbury Park, N. J.

Dear Mr. Pacini:

THE POINT which I wished to make was simply that in neglecting the plate conductance (by substituting μ for μ plus one) and the conductance of the cathode resistor we are needlessly sacrificing precision of analysis. It is customary, as you say, to neglect the difference between μ and μ plus one in cathode follower calculations but I do not believe we should also throw out the effect of the cathode resistor and say that the output impedance is the reciprocal of the transconductance. This can easily lead to an additional 5 percent error.

Since the analysis is not appreciably simplified by these approximations why not take the precise expressions for amplification and output impedance as guides for design? We can neglect the minor terms if we want but at least we will know what we are neglecting.

RUSSELL N. SKEETERS
Pasadena 4, California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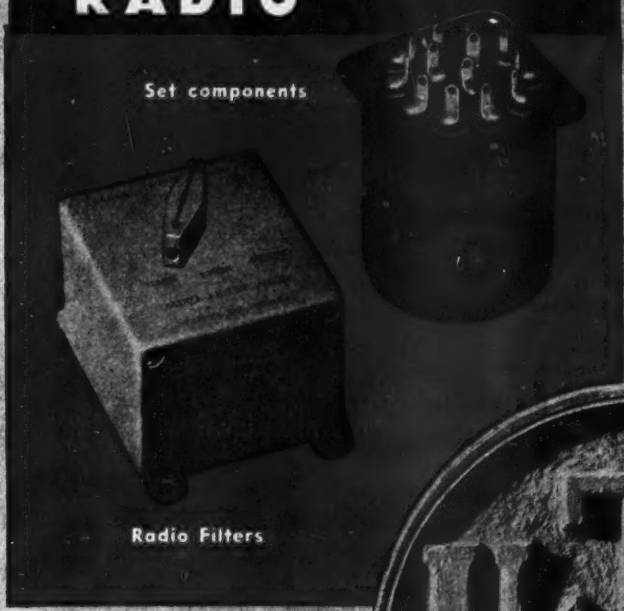

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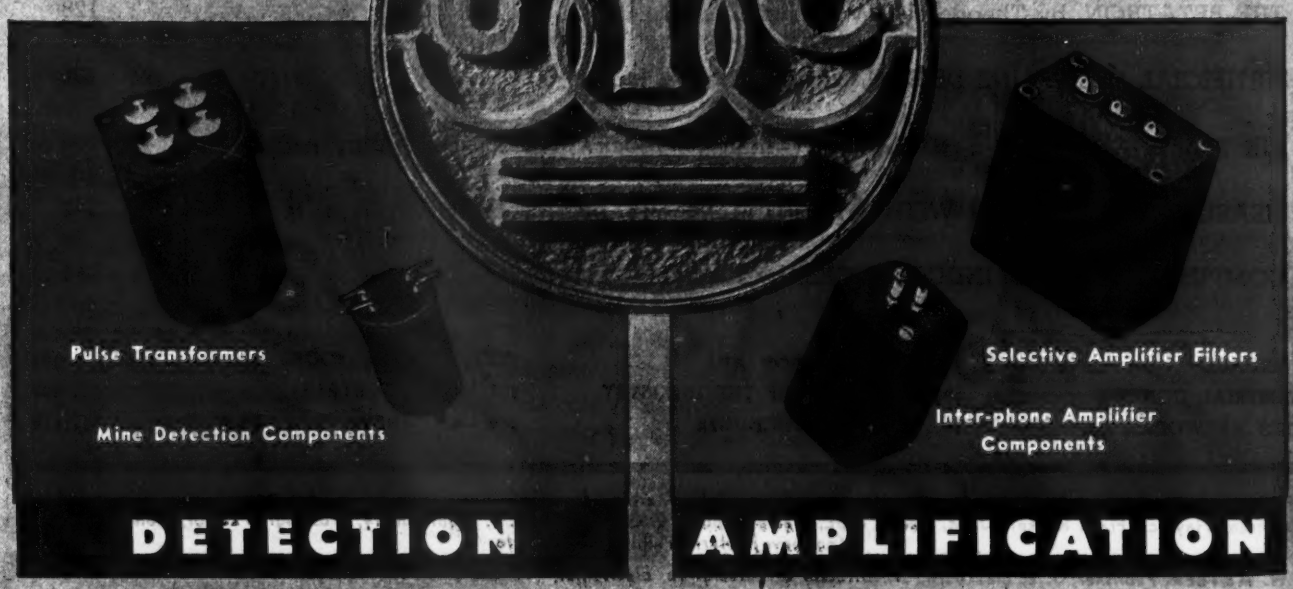

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